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VOL. VIII.

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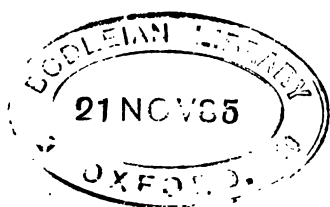
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## PREFACE.

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THE present series of Health Lectures is devoted to the subject of House Construction, with especial reference to their healthy occupation, and in the hope of rendering the volume more useful to all householders, a lecture by Professor Munro, of the Owens College, on "The Legal Position of Landlords, Tenants, and Sanitary Authorities," has been added to the series. The lectures were delivered at the Manchester Technical School to large audiences, composed chiefly of architects, plumbers, and men engaged practically in the various branches of the building trade. We may fairly anticipate that in consequence of these lectures increased attention will be paid to make our homes more healthy and therefore happier.

To the householder himself this volume will supply a means of testing and checking the various operations of workpeople employed about his house.

A. RANSOME,  
Chairman of the Committee,  
Manchester and Salford Sanitary Association.

*August 28th, 1885.*



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# SOILS AND SITES.

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By ARTHUR RANSOME, M.D., M.A., F.R.S.

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IT is intended in the present series of Health Lectures to make the dwelling-house the centre around which all our discourses are to play—its site, its foundations, the materials of which it is constructed, the ground plans and elevations of the edifice, its drainage, heating, lighting, and ventilation, its plumbing, its decoration and furnishing, and, lastly, the legal conditions under which it may be inhabited. On all these topics it is hoped that the several lecturers may have something practically useful to say, and something that may be of widespread usefulness to the community. It is my business to-night, not only to begin the course for the present season, but theoretically, if not actually, to lay the foundation for the superstructure—at least, to point out where it will best be placed.

We all of us have to inhabit some kind of dwelling-house ; and though there are not many of us who can choose the one that may seem to us the highest ideal of what a dwelling should be, we shall none of us be the worse for knowing something of the subject—what dangers may have to be encountered, what advantages may be secured, and how a dwelling may be most healthfully and economically constructed.

The subject that has been entrusted to me is “The Site of the House,” the place on which it should be erected, and the nature of the soil in which its foundations are to be based.

In selecting a site, or in choosing a dwelling, there are not many men who care to look much below the surface. Those persons whose fortunate lot it is to be able to live in the country, generally regard the aspect towards which the living rooms will look, whether the views from them are pretty, whether the garden is good and suitable for the growth of plants and vegetables. They

enquire as to the water supply, and the nearness to a town or village or railway station from which eatables may be procured. Possibly, too, a thought may be given to the question of drainage; but there are not many people who are themselves competent to judge as to its adequacy.

To those who have to live in a town, the first considerations are probably the position of the dwelling in reference to their business, its rental and adaptability to the needs of the household, and whether the neighbourhood is suitable for their position in life; and after all these points are settled, there may come in some questions as to the healthiness of the situation, and the arrangements for the disposal of refuse.

But we shall have to look much beyond all these things if we would secure life's chief blessing of health to those who are to form the family circle of such a home. In the country we shall have to take account of the aspect of the house in regard to the possible danger from malaria. We shall have to examine the nature of the subsoil upon which the house is built, or is to be constructed, its composition, its structure, its moisture, and the way in which it can be drained away; and in towns there is always the possibility of previous contamination of the ground, and the danger that poisonous emanations may pass from the ground into the precincts of our habitation.

I propose to take up each of these topics in their order, and although it will not be possible within the short limits of a single lecture to deal exhaustively with the subject, I hope that I may be able to say sufficient on each point to put you on your guard against some of the more common dangers to health that lurk within or on the surface of the soil.

1. As to *aspect*. We all know the advantages of a southern aspect for a house, and we can appreciate the importance in this climate of having as much of the warmth and light of the sun as we can get. But it may not be equally well known that the sun's light is an important sanitary agent. It has been shown recently by Dr. Downes and Mr. Blunt that the minute organisms that produce putrefaction cannot live in the full glare of sunlight, and it is highly probable, therefore, that many disease germs, which are closely allied to them, will be equally affected by light. Other observers, notably Dr. Graves, of Dublin, and M. Fourcault, have on the other hand given good reasons for believing that the absence of light produces a tendency to the production

of deformities in children. By all means, therefore, secure as much light in your dwelling as you can get.

Another point to be regarded with respect to the situation, and especially with regard to the aspect of a house, is its relation to the surrounding country. Not only must the site itself of the house be well drained, but the country near must be healthy in its character, and this condition depends not only upon its climate, its temperature, the dryness or moisture of the air, but upon the presence or absence of vegetation, the neighbourhood of trees and forests, and the like.

2. *Drainage.*—The influence of drainage is very great. The Hospital at Cambridge, fifty years ago, was never without its cases of ague; but when I first went there, in 1853, we hardly ever saw a case, and this freedom from the disease was entirely due to the more perfect drainage of the Fen country. Even an elevated site is not always free from danger in this regard.

Captain Galton, in his work on "Healthy Dwellings," gives two instances of this fact. Thus, "in order to provide a healthy station at Jamaica, an elevated site from 3,500 to 4,000 feet above the sea-level, at a place called New Castle, was selected for barracks. It was situated on the crest of a spur of land falling rapidly from the blue mountains southwards towards the deep damp valleys and ravines, filled with tropical vegetation, which connect the range with the lower country. The sides of the ridge sloped down at angles  $40^{\circ}$  and  $50^{\circ}$ . The surface was clay mixed with vegetable matter. The ridge was so narrow that the huts were placed on terraces cut out of the slopes of the hill, with but a few feet of space between the back of the hut and the soil supporting the terrace above. Even in temperate climates such a position contributes to fever. The result was that in the yellow fever epidemics in 1856 and 1867, those huts which were so placed that the malaria blowing up the valley must necessarily strike them, yielded a large percentage of yellow fever even at this high elevation.

"Again, Boná, in Algeria, stands on a hill overlooking the sea; a plain of a deep rich vegetable soil extends southward from it, but little raised above the sea-level. The plain receives not only the rainfall which falls on its surface, but the water from adjacent mountains, and is consequently saturated with wet. The population living on it and near it suffered intensely from fever; entire regiments were destroyed by death and inefficiency. It was at

last determined to drain the plain. The result of this work was an immediate reduction of the sick and death rate.

"But some time after this the drains were left to atmospheric influences; they became partially obstructed and irregular, and did not allow the water to reach the outfall; the result was a violent outbreak of fever at Boná, attended with great loss of life, both civil and military. An enquiry took place, the drainage was rectified, and since then Boná has been healthy."

Very often land is water-soaked, and consequently unhealthy simply on account of the impervious nature of the underlying ground. By breaking through this so as to afford an outlet, a settling of the imprisoned water into the looser soil below gradually takes place, and the causes which render the soil above unfit for cultivation, and deleterious to health, are removed. The following is an interesting instance of this action.\*

"A recent letter from Rome says the monks of La Trappe have lately discovered the means of making the vast Roman Campagna healthy, a work that has baffled all the governments from Romulus to Victor Emanuel or King Umberto." The evil effects of malaria in this region are well known. "The soil of the Campagna has but little depth; under it lies a stratum of tufa, in some places two mètres (over two yards) in depth. Under this tufa is other volcanic material equally hurtful to vegetation. Thus there is no subsoil, and no chance for circulation of water and air. When the heavy rains fall the water rests on the tufa, and generates unhealthy mists. When the droughts come the soil is baked to ashes.

"The wise, good, industrious Trappists began to improve that very unhealthy land of the Three Fountains, first with Eucalyptus raising, and made the place comparatively healthy. Lately they have tried, with success, a most remarkable experiment. They have bored the tufa, at different distances, a mètre and a half deep; in these holes they have placed dynamite, and by electric conductors have exploded the volcanic strata. A dull rumbling is heard, a little elevation of the ground is seen, in some places the earth is thrown out a short distance. In eight days' time they found a subsoil for a large space of ground, and made it both susceptible to culture and healthy.

"Thus these simple, busy Fathers of La Trappe have done the

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\* "Hygiene." By Dr. Buck Vol. i., p. 423.

useful work that lay before them, and have solved a problem as old as Euclid, and hitherto as fatal as the Sphynx. Their silent labours will give health to future generations, and cover with luxuriant fields of grain the vast Agro Romano."

3. *Exposure*.—Another point of not less importance to health is the free circulation of air around a dwelling. The following story told by Galton both shows this fact and the necessity for drainage. "Fig. 1 shows the slope of the ground falling towards the plain of Balaclava. The foundations are rock below and above, traversed by a belt of clay and shale. The 79th Highlanders were placed on the clay, and as the material was soft, their huts were placed on terraces cut out of or

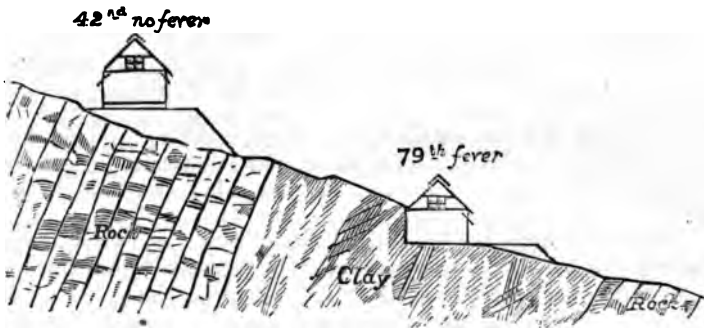


FIG. 1. Huts on Hillside at Balaclava.

the hillside, and were thus embedded in the ground, and the floors consequently were always damp. There was no roof ventilation. This regiment had half the men down with fever. The 42nd Highlanders were placed on the rock, and as it was hard they did not cut into the rock, but preferred building their huts on projecting terraces, so that they were quite dry, and air circulated freely around. This regiment did not suffer from fever. The huts on the clay were subsequently altered (Fig. 2) so as to allow free circulation of air. Drainage and roof ventilation were provided as here shown, and fever no longer prevailed."

4. *Subsoil*.—When we come to questions about the healthiness of the site itself, we find that there are still many points to be considered. The structure and composition of the underlying geological strata are of some importance, but not quite so much as some

persons suppose. When we examine the data given by Dr. Parkes ("Hygiene," 5th ed., p. 337) on this head, we find that there are very few positively unhealthy grounds, if they are natural and not artificially laid down, or polluted from some external source. Thus

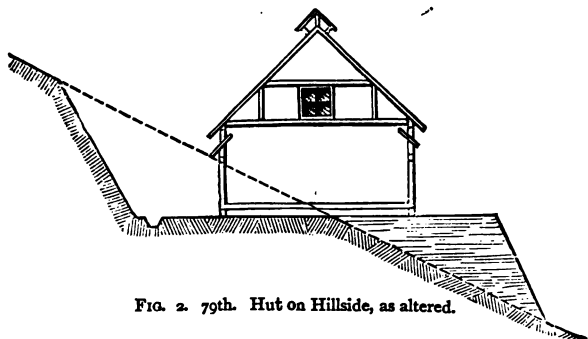


FIG. 2. 79th. Hut on Hillside, as altered.

all the following are marked as *healthy*: granitic, metamorphic, and trap rocks, clay-slate, limestone, and magnesian limestones, except in the neighbourhood of marshes; chalk, sandstones, and gravels.

There are both healthy and unhealthy sands, and clays, dense marls, and alluvial soils are always to be regarded with suspicion.



FIG. 3 shows the nature of healthy and unhealthy sites respectively.

Well-cultivated soils are often quite healthy, but irrigated lands are usually hurtful. But the ground in the neighbourhood of towns is not by any means usually left as nature made it. There are large tracts of land that have been levelled down and others

raised, hollows filled up with any kind of rubbish that came handy.

Some of these are pits out of which brick-clay has been dug, or low-lying, swampy ground that had to put on an appearance of dryness; such places then are made into tips for all kinds of rubbish, brick-bats, cinders, the material dug out of other foundations, and not unfrequently much less innocent substances than these, the contents of ashpits, and road-scrapings, containing both vegetable and animal refuse.

Much of this material, therefore, is in a state of putrefaction, and it has been found by experiment that the organic putrefiable substances do not entirely disappear even in three years' time from their first being laid down.

Such ground as this is the very worst upon which houses could be built, and yet it is very common in the suburbs of all towns, and is often the subject of alluring advertisements of "eligible sites for building." It was in consequence of a report by Drs. Parkes and Sanderson, on the sanitary condition of Liverpool, that the Local Government Board included the following clause in their model bye-laws respecting new streets and buildings: "9. A person who shall erect a new building shall not construct any foundation of such building upon any site which shall have been filled up with any material impregnated with fœcal matter, or impregnated with any animal or vegetable matter, or upon which any such matter may have been deposited, unless and until such matter shall have been properly removed, by excavation or otherwise, from such site."

Many other towns have adopted this and other salutary clauses in their bye-laws, but I am sorry to say that they are as yet wanting in the building bye-laws of this great city.

Numerous complaints have been made respecting the nuisance to health due to the emanations from made ground in the neighbourhood of dwellings, and several cases of sickness have been traced to this cause, but so far the applications for redress of the evil made by our own Sanitary Association, and by the Society of Architects in the city, have met with no adequate response.

Dr. Mapother, of Dublin, has also shown the evil that arises from building dwellings on the sites of old watercourses, or pools imperfectly drained.\* He has proved by figures that in the

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\* "Public Health," p. 367

visitation of that town by cholera, in the year 1866, three-fourths of the deaths from this disease occurred within 200 or 300 feet of such watercourses, some of them having been allowed to fill up; and others having been converted into sewers that "do not sufficiently carry off the land drainage, or which, being of the flat-bottomed and leaky kind constructed in the last century, may pass their contents into the surrounding soil."

But before we go into the evidence proving the connection between disease and the condition of the soil, it will be well to enquire in what way this influence may be exerted, and how poisonous vapours can be generated, and can exhale into the air so as to reach the dwellers in houses.

And, first, we must cease to regard the earth beneath us as exclusively solid matter. It is everywhere more or less porous, and permeable by both air and water. Sand will take up 25 per cent of its own weight of water; finely precipitated chalk, 85 per cent; pure clay, 70 per cent; garden earth (humus), 181 per cent; and turf, 200 per cent, or double of its own weight of water. (Schübler.) Even a well-baked brick will take up as much as half a pint of water. Naturally, where water will pass, air will pass so much the more readily. The whole art of drainage depends upon this porosity of the soil.

5. *Ground Air.*—But the ground air is not exactly like the air of the atmosphere around us. It is true that it is a mixture of the same gases—oxygen, nitrogen, and carbonic acid; but in atmospheric air there are usually only four parts per 10,000 of carbonic acid, and 20 per cent by volume of oxygen. In ground air the oxygen at a depth of a few yards diminishes in some cases to 15 per cent, and the carbonic acid may rise to as much as 8 per cent—200 times more than in atmospheric air. This tendency to substitute carbonic acid for oxygen increases the deeper we get into the ground.

Prof. Pettenkofer, to whom we owe much of our knowledge of underground physics, found that in the neighbourhood of Munich the carbonic acid varied from 1·58 per 1,000 volumes, at a depth of 5 feet, to 18·38 at a depth of 13 feet. At this last-mentioned depth, then, the air would be quite irrespirable, and it would at once extinguish a light. It was at Dresden that Fleck found the large proportion of 80 parts of this gas per 1,000. There are a good many cellars that go nearly as deep as 13 feet into the ground, and the cellar air often to a great extent passes into the house

above. You may imagine the danger of breathing such impure air as this, and how important it is to keep it out of the house!

It is perhaps the duty of the lecturer on foundations to tell you how to do this. But I may mention that there are three ways of managing it: (1) by putting a thick layer of concrete under the cellar floor; (2) by having a cavity under this floor communicating with the kitchen flue; and (3) Dr. Richardson's, in his "*City of Hygeia*," by building the house entirely above ground, without any cellars, and supported upon arches. I may mention that in the new model wards recently built at the London Fever Hospital, two of these plans are combined, for the arches supporting the wards are built upon a layer of concrete, extending several feet beyond the area of the building.

In the model bye-laws, which I have already quoted, the tenth clause runs as follows: "10. Every person who shall erect a new domestic building shall cause the whole ground surface or site of such building to be properly asphalted, or covered with a layer of good cement concrete, rammed solid, at least six inches thick."

I am told that this precaution cannot add much to the cost of a house, since a cubic yard of concrete only costs from ten to fifteen shillings, and at six inches thick this would cover sixty-four square feet. This clause is also absent from the Manchester bye-laws. But the ground air is by no means stationary—it is continually in motion. A good proof of this fact is given by Pettenkofer, when he shows that it is possible to preserve a bird alive in a glass cylinder, enclosed at a depth of several inches of gravel; and he mentions that some years ago, in Saxony, two men who were shut up in the shaft of a well for ten days, owing to the falling in of the earth, were kept alive and were not much the worse for it when they came out again. ("On the Relations of the Air to the Soil," p. 75.)

He also gives the experiment of blowing through gravel into a tube connected with a manometer, and this experiment I will show you. It proves at least the possibility of the air moving through one kind of soil.

And there is evidence still more to the purpose that ground-air both can and does travel long distances to enter into dwelling-houses. Just now I mentioned the possibility of air coming from cellars into a house: the following circumstance narrated by Pettenkofer shows how far it may travel when sucked in by the in-draught caused by warm and ascending air inside a house.

"In December, 1859, the chaplain of St. Ulrich's church, at Augsburg, was suddenly seized with a serious illness, the nature and cause of which were inexplicable. The sisters of mercy who nursed him were, one after another, seized with the same symptoms—pain and congestion of the head, fainting, etc. The symptoms always became aggravated when the weather got colder. After some time, no improvement having appeared, a friend who came to see him one day exclaimed on entering the room—'There is an escape of gas.' This was denied by all connected with the house, and declared by the doctor to be immaterial, as the patient was now pronounced to be undoubtedly suffering from fever. At length, however, a person was sent for to the gas office, and he at once said there was an escape, but confessed himself unable to discover its source. The patient, however, acted on the hint, and having left the house, in spite of the doctor, recovered in a few days. No sooner was he gone, and the windows of his apartments thrown open, and the fire let out, than his next neighbour got attacked by the very same symptoms. He, too, recovered at once by a rapid flight from the house.

"It was impossible to examine the underground pipes at the time, as the ground was frozen hard. However, at the end of six days this was done, and an escape was discovered in the main pipe, which ran in the centre of the street, some twenty feet distant, the gas escaping in such quantities as to burn briskly when lighted.

"The coldness of the weather had necessitated larger fires in the house, and the increased heat developed a current of air from the ground into the house, the gas being sucked up with it. When the patient had left the house, his room was allowed to cool, and the current of air and gas was thus diverted to the apartments of his neighbour."

But it will be readily understood that if coal gas can thus travel long distances underground, and that it may be drawn into houses by the suction of the warm air, any other air that the ground may contain will with equal facility be thus conveyed.

And there is further the certainty that this air may carry with it not only vapours, but any minute particles that can be floated along in its current. That there are such particles, germs that are the active causes of diseases, has also been abundantly proved; you will see, then, how important it is either to see that the ground air is perfectly pure, or, as that is well-nigh impossible, to exclude

it altogether from our houses. The ground in the neighbourhood of dwellings is in constant danger of becoming contaminated with noxious matter—the soakage from midden heaps or ash-pits, or even from fecal matter, is constantly passing into the ground of towns, and the sewers themselves may, and not unfrequently do, leak and allow their contents to drain away into a porous soil. If any of these substances contain the germs of fevers, dysentery, diarrhoea, or cholera, we have seen how readily through the agency of our household fires they may get into the houses themselves. You probably all know that the severe attack of typhoid fever from which the Prince of Wales narrowly escaped with his life came from sewer-gases that were drawn into his well-warmed bedroom from a neighbouring closet; but, after what I have said as to the movement of the ground air, it will be apparent that not only sewer-gas, but vapours from the soil itself, are almost equally potent for harm. We shall presently have abundant proof that many diseases do actually come from this source.

6. *Ground Water.*—The next important agent in the soil is the ground water. Except in very hot climates, or occasionally in very hot summers in this country, all soil is more or less damp, and generally even in the hottest weather we have only to dig a few inches into the ground before we find a certain degree of dampness. But at a certain depth below the surface—a depth that varies in different soils—we come at last to a point at which the ground is evidently saturated with water. Any space made by the spade speedily fills with water flowing into it from the porous soil around.

This is the surface of a sort of underground lake that is everywhere spread beneath us, only, unlike a lake, it is not level, but rises to different heights below the surface of the ground. In a marsh it rises quite to the surface, and in a sandy soil its depth depends upon the distance of some more impervious layer of rock or clay. The level of the ground water, then, being determined by the nature of the underlying strata, may be at very different depths below the surface, and in some cases is at a very great depth. It also varies very much in height at different seasons. Its height is, in fact, dependent upon the rainfall and upon the obstructions to its course, and ultimately it tends to fall into the nearest water-course. It is, however, usually much higher at some distance from the river towards which it flows, because of the slowness of the rate at which it percolates through the soil. In Munich the

rate of movement towards the Isar river is only 15ft. daily, and the rapidity of its rise and fall differs very much in different places and at different seasons of the year. In some places it scarcely changes its level; in others, as in India, where the rainfall at the rainy season is excessive, it may vary to the extent of 17ft. (as at Sangor, in India). In Munich its greatest variation is 10ft. This ground water is always highly charged with carbonic acid gas, though not to the same extent as the ground air, and it might be supposed that it obtains its supply of this gas from the ground air, were it not that its charge of the gas is not always greatest when nearest to the more pervious part of the soil.

7. *The Relation between Soil and Disease.*—It is now time to enquire what practical conclusions we can draw from all these details about the air and water in the soil. They are none of them without significance, and especially with reference to our immediate purpose of finding out the influence of soil upon the health of the human beings who crawl about over its surface.

An old friend of mine—the late Isaac Taylor, a former resident in Manchester, for whose memory I have a profound respect—once said to me, “When people talk about going from home for change of air, what they really mean is change of earth. The air we breathe is approximately the same everywhere out of doors (diagram); it is the character of the underlying ground that we change.” It behoves us, then, to enquire how this change may affect us. Mr. Taylor thought that there might be differences in the electrical currents passing through the earth, and there are unquestionably differences in the receptivity of soils to heat. But I do not propose now to enquire into these still unsettled problems. It more concerns us to see how far the soil can promote or hinder the growth of those organisms that we now know to have such a pernicious effect in causing disease.

Now, all soils, besides air and water, contain a certain proportion of organic matter, *i.e.*, certain compounds of carbon and nitrogen and hydrogen, as well as purely mineral matter, and in order that even the lowest forms of life may exist there must be present a certain degree of warmth, a certain amount of air, some moisture, and often some organic particles to serve as food. These are the conditions under which life may exist, and they are all found in soil. Different soils will take up different degrees of warmth from the heat of the sun; but, in most ground, during summer and autumn, there will be sufficient heat, at any rate in this climate, for

the hatching and growth of the microscopic germs of putrefaction and disease. It is supposed by Dr. Parkes that it is from the former of these actions that proceeds the carbonic acid gas, which we have found to exist in such large proportion in ground air. This question, which is still unsettled, is, however, of much less importance than the question of the origin of different diseases in the soil. To this point we will now turn our attention. The disease that has been longest known to be closely connected with the state of the ground is intermittent fever, marsh fever, or ague.

8. *Malaria*.—If you glance at Dr. Lombard's map of the distribution of malaria—as it is called—that is, air charged with the elements of ague, you will see how widely it is spread, chiefly around the coasts of hot countries and at the mouths of rivers, especially those where there are marshes. It is well known that such marsh lands are particularly unhealthy when their *surface*, previously saturated with water, is exposed to the direct heat of the sun, and thus the soil is for a time partially dried up. Ferguson says, "that this is an indispensable condition in hot climates." (Buck, "Hygiene and Public Health," vol. 1., p. 436.) Digging up the soil also, excavating for canals, building dykes, the clearing and preparation of lands for their first cultivation, by exposing earth, containing matters that have long remained in a quiescent state, to the energetic action of the sun, all these operations increase the danger from malarious poison. Thorough, deep drainage, on the other hand, as we have already seen, removes the danger of infection.

It has been doubted whether it is inhaling the air or drinking the water from marshes that has the most influence in producing fever, but the instance already quoted from Galton, and other cases in which fever was only produced when the wind was blowing over a marsh, are sufficient to prove that whatever the water may do, the air is able to convey the disease.

The true cause of marsh fever has now been found to be an organism—one of the numerous race of *Bacillus*—the *bacillus malarie*. It is found in the shape of small shining movable spores, which when injected into the blood grow into peculiar dumb-bell shaped rods.

These creatures have been found in both stages in the blood of persons suffering from ague—as rods in the cold stage, and as spores in the intermissions of the disease. We can readily understand now how they may exist in marshy soil, how they are

set free by turning over the ground, and how they may be conveyed into men's bodies by means of drinking water or in the air.

9. *Diarrhœa* and *dysentery* constitute another group of common diseases causing an enormous mortality, especially amongst children, and having much to do with the condition of the soil. In his report to the Privy Council in the year 1859, Dr. Headlam Greenhow showed that in some districts the mortality from these diseases is nine times as great as in some others, and he shows that this excessive mortality is coincident (1) with the tainting of the atmosphere with the products of organic decomposition, especially of human excrement, and (2) with the habitual drinking of impure water.

Both these conditions have ultimately to do with the state of the ground, for in most instances the impure water spoken of was drawn from wells, and these were often contaminated by admixture with ground water, tainted and poisoned with substances that had passed into the soil.

Leicester is a town that has for some time borne an unenviable notoriety as a place where the infant mortality from diarrhœa is excessively high, and successive medical inspectors have attributed this notoriety to the fact that parts of the town are built upon made ground, such as I described just now.

There is also a further reason for ascribing these diseases to some zymotic or fermentative element in the fact that it is only in the summer months that there is any great prevalence of these complaints. In the year 1859 I pointed out, as a result of an enquiry into the influence of atmospheric changes upon disease, that diarrhœa did not begin to increase materially in prevalence until the mean temperature of each week was 60°, and this observation has since been confirmed by others. In a recent report by the medical officer of Leicester the temperature of the soil has been ascertained, and he also ascribes the excessive mortality of the town from this disease to the fermentative changes going on in the filth-sodden ground.

In all towns there exists this danger, and although in Manchester great improvements have been made in the abolition of the old privies and ashpits, we can hardly doubt that much of the ground where these have existed is still saturated with the overflowing refuse from these pits of abomination.

10. Ground water has also been shown to play a very important part in the production of *typhoid fever* and *cholera*.

I have here a chart showing the rise and fall of typhoid fever side by side with the height of the ground water, for a series of 16 years; and you will see that in every case in which the disease was prevalent the ground water was lower than usual, and not only so, but the rise of the ground water always seems to bring with it a diminution in the mortality from this disease.

Prof. Seidel, from data covering a period of eight years, has calculated that the probability is 36,000 to 1 that there is a connection between variations of level of soil water and the prevalence of the disease. To account for this fact, Prof. Pettenkofer supposes that the germs of typhoid fever, scarcely at all contagious in their recent state, need to be in contact for a time with soil favourable to their further growth. This they find in the ground recently abandoned by the ground water, and after flourishing there for a time they acquire such virulence that, upon rising into the outer air or passing into drinking water, they are able to give the disease to human beings.

It must be pointed out in reference to this theory that there are cases, such as the outbreak of typhoid fever at Zurich, of which I show a diagram, in which the converse of the above-mentioned observation has taken place, the disease rising and falling with the ground water.

In either case, however, we cannot doubt that the ground water has had something to do with the disease; probably, in the one case, draining from a large area into the wells, and in the other rising through infected ground, and also ultimately getting into the drinking water.

There are now many scores of well-authenticated cases in which typhoid fever has been traced to the water from wells. In *cholera* also the condition of the soil has an important influence upon the spread of the disease. In England there is a well-founded belief that one of the chief agents in conveying this disease is drinking water. The notorious outbreak of cholera in London, that was traced to the Broad Street pump, shows the power of water in spreading this disease. This, the most terrible outbreak which ever occurred in this kingdom, carried off in ten days upwards of 500 people, all residing within 250 yards of this notorious pump. "The mortality in this limited area," says Dr. Snow, "probably equalled any ever caused in this country, even by the Plague, and it was much more sudden, as the greater number of the cases terminated in a few hours. It would also, undoubtedly, have been

much greater had it not been for the flight of the population." Now, all this fearful havoc was traced to the water from the pump in question, and affixed to it by a chain of evidence most complete, the witness to it being not only the fact of persons drinking the water being seized by cholera, but cases of immunity, such as that of a brewery in the centre of the district, the seventy men employed in it never taking the pump water, and all, without exception, escaping the infection. There were also other striking instances of persons who lived out of the district contracting this disease, but who had managed to obtain some of the water.

Dr. Simon has shown that in London the houses supplied with water drawn from the river, polluted with sewage, furnished a death-rate from cholera of 13 per 1,000; while in other houses, situated in quite similar circumstances, sometimes only on the opposite side of the street, but supplied with pure water, the rate was only 3·7 per 1,000. Similar evidence is given with respect to Königsberg and Berlin. Dr. Buchanan's diagram, showing the results of improved drainage and water supply, also testifies to the influence of these reforms in preventing cholera. But none of these instances exclude the possibility of other influences being at work, and we have a strongly-expressed opinion from Professor Pettenkofer that the true cholera poison is not rendered virulent by water, but by the soil. He believes that the only influence that drinking water can have on the spread of the disease is by acting as a means of conveyance of the germs engendered and hatched elsewhere. There must doubtless be an original source for the poison in some cases of cholera; he does not suppose that it can be formed *de novo* out of soil, and he admits that it only spreads by human intercourse. But cholera, like typhoid fever, is certainly not very contagious from person to person, and Professor Pettenkofer believes that the quality that renders it virulent is generally, if not always, found in the soil; and in order that this may have its full effect there must be a certain degree of warmth and dampness, and this latter condition is best fulfilled when the ground water subsides suddenly after a previous rise. A porous soil, into which the specifically infected filth can sink, is therefore the most dangerous.

The evidence upon which this theory rests is certainly very strong, though, as we shall see presently, it does not confirm Pettenkofer's views as to the exclusive influence of the soil. Thus, in Bavaria, the theory was submitted to a commission of enquiry as

to the distribution of cholera, and it was found to be, indeed, true that all the places infected by cholera were places on porous soil, and in certain villages in mountainous districts, which appeared at first sight to be exceptions to the above rule, it was discovered that the disease arose where the houses were built upon clefts in the rocks filled up with alluvial soil.

At Buda-Pesth, it is stated by Foder that the cholera mortality rises and falls inversely with the ground water, increasing as the water declines, and lessening with its rise; and a similar observation was made by Messrs. Lewis and Cunningham in an outbreak of cholera at Calcutta in 1873-74. In the cholera epidemic of 1854 Dr. Farr noted the fact that one large district in London, built on gravel, was severely visited by cholera, but that an institution, built upon a sort of island of brick clay, in the midst of it, was entirely exempt. There are, however, few rules without exceptions, and that filth alone, without soil, is quite capable of nourishing cholera may be shown by the fact that during the first visitation of cholera in England one of the places which suffered most severely, owing to its filthy local conditions, was Megavissey, on the granitic formation in Cornwall. (Galton's "Healthy Houses," p. 21.) Moreover, Dr. B. W. Richardson (Trans. Epid. Soc., vol. ii.) points out that in the Crimea certain ships supplied with distilled water were exempt from the disease, with one exception, and in this instance the water had passed through a foul hose-pipe.

It will be useful, however, to bear in mind the possibility that certain diseases, such as typhoid fever and cholera, may have their virulence intensified by contact with the organic matter of soils, and in this regard it may be interesting to recall Dr. Thiersch's observation that "cholera stools develop a special activity after being kept for from two to six days," an observation confirmed by an English physiologist, Dr. Burdon Sanderson. It is well known also that linen soiled by the discharges is especially infective and that washerwomen often fall victims to the disease.

11. Another disease that is undoubtedly fostered by dampness in the soil is *consumption*. In the year 1862, Dr. Bowditch, of Massachusetts, made an elaborate series of enquiries as to the causes of consumption. Questions were addressed to medical men in all parts of the country upon much the same plan as that now adopted by the Collective Investigation Committee of the British Medical Association, and as a result of these inquiries, he

came to the conclusion that—(1) “A residence on or near a damp soil, whether that dampness is inherent in the soil itself or caused by percolation from adjacent ponds, from marshes, or springy soils, is one of the primal causes of consumption in Massachusetts, probably in New England, and possibly in other portions of the globe. (2.) Consumption can be checked in its career, and possibly, nay probably, prevented by attention to this law.”

Shortly afterwards, and without any knowledge of Dr. Bowditch's conclusions, Dr. Buchanan, who is now the chief medical officer to the Local Government Board, came to much the same conclusions as the result of an elaborate research into the distribution of consumption in the three south-eastern counties of England beyond the limits of the Metropolis.

His conclusions are well worthy of being quoted *in extenso*—they are as follow :—

(1.) Within the counties of Surrey, Kent, and Sussex, there is, broadly speaking, less phthisis (*i.e.*, consumption) among populations living on pervious soils than among populations living on impervious soils.

(2.) Within the same counties there is less phthisis among populations living on high-lying pervious soils than among populations living on low-lying pervious soils.

(3.) Within the same counties there is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.

(4.) The connection between soil and phthisis has been established in this enquiry—(a) by the existence of general agreement in phthisis mortality between districts that have common geological and topographical features of a nature to affect the water-holding quality of the soil; (b) by the existence of general disagreement between districts that are differently circumstanced in regard of such features; and (c) by the discovery of pretty regular concomitancy in the fluctuation of the two conditions, from much phthisis with much wetness of soil, to little phthisis with little wetness of soil. But the connection between wet soil and phthisis came out last year in another way, which must here be recalled—(d) by the observation that phthisis had been greatly reduced in towns where the water of the soil had been artificially removed, and that it had not been reduced in other towns where the soil had not been dried.

(5.) The whole of the foregoing conclusions combine into one—which may now be affirmed generally, and not only of particular districts—that “wetness of soil is a cause of phthisis to the population living upon it.”

(6.) No other circumstance can be detected, after careful consideration of the materials accumulated during this year, that coincides on any large scale with the greater or less prevalence of phthisis, except the one condition of soil.

Good drainage has been found to diminish the prevalence of the disorder by as much as 50 per cent. These results have since been confirmed by Dr. Haviland, and by the Registrar-General of Scotland. In the conclusions drawn from his map of the distribution of phthisis in England and Wales, Dr. Haviland says: “Damp, clayey soil, whether belonging to the wealdon, oolitic, or cretaceous formation, is coincident with a high mortality;” and the Registrar-General, in his seventh report, remarks that “the towns, villages, hamlets, or houses which were situated at or near undrained localities, or were on heavy, impermeable soils, or on low-lying ground, and whose sites were consequently kept damp, had a very much larger number and proportion of cases of consumption than towns, villages, hamlets, or houses which were situated on dry or rocky ground, or on light porous soils, where the redundant moisture easily escaped.”

It is evident from all this evidence that there is some close relationship between the condition of the soil and consumption; but how a damp subsoil can increase the prevalence of the disease is not so clear. Whether it is by simply increasing the tendency to colds and bronchitis, which are frequently the precursors of tubercular disease, or by directly fostering the germs of the disease itself. It is now known that the immediate cause of consumption is another of the small organisms, a bacillus similar to those associated with typhoid fever and cholera. But it can hardly be a sojourn in damp soil that promotes the growth of this particular bacillus of tubercle. Prof. Koch, who discovered it, has shown that it cannot be cultivated except between the temperatures of 86° and 107° Fahr., and these temperatures are far higher than any that we have in the soil of this country. It must then be in some indirect fashion that the soil affects the prevalence of the disease; and it is not unreasonable to conclude that the increased tendency to catarrhs on damp soil has something to do with the result. But there are probably other influences also at work.

The vapours that arise from damp ground, and which we have seen to make their way into houses, are often very impure, and charged with organic matter that may be a suitable food for the tubercle bacillus; and in most houses there are warm nooks where there would be sufficient heat to hatch them into activity.

Whether this is the true explanation of the connection between dampness of soil and consumption or not, it is certain that although the disease is not infectious in the ordinary sense, it may be introduced into houses and places where it had not previously existed, and therefore we cannot ascribe the promotion of the disease solely to the influence of "catching cold."

The following cases recorded by the Collective Investigation Committee are sufficiently significant on this head.

(1.) "In 1862 a servant came home to her mother (a widow, with three sons and two daughters, all grown up, father died of epithelioma) suffering from phthisis. The house, consisting of two rooms and an attic, and lying under the brow of a hill, on its northern aspect, was ill-ventilated and worse lighted. By the end of 1868 the only survivor of this family, she being still alive and healthy, was a thin delicate girl, who took little or no part in the nursing. They all died of phthisis, the mother dying last between fifty and sixty years of age."

(2.) "A young man, of the Indian navy, came home suffering from phthisis. In a few months two of his sisters were taken with the same complaint and died. A third sister married and soon afterwards died of the same disease. The young man also died. Later on the father was similarly affected and died. After his death the widow became phthisical and died also. I should think four years covered the whole outbreak, that is, from the arrival of the son from India. The father was originally a very healthy, strong man, and all the children healthy up to about twenty or twenty-one, or even later; one sister still lives, and is now between forty and fifty."

In these cases truly something seems to have been introduced from without into dwellings previously untainted by the disease.

12. There are yet other diseases whose fatality, at any rate, is increased by the condition of the soil, especially by dampness of the soil.

Dr. Blaxall in a recent report gives an interesting proof of this statement. He is comparing two parts of the same town, Swindon. Old Swindon, situated on limestone and sand, is at an

elevation of about 100 feet above New Swindon, and this latter portion of the town is built on Kimmeridge clay, and was formerly much subject to floods.

Dr. Blaxall shows that measles, whooping cough, and pneumonia, diseases especially affecting the respiratory organs, were far more fatal in New Swindon than in Old Swindon. During six years preceding his investigation the death-rate from measles in New Swindon was as much as twenty times that in Old Swindon, from whooping cough more than double, and from pneumonia and bronchitis one-third as much again. He is led to the conclusion that this increased severity of these diseases in New Swindon is chiefly attributable to the dampness of the subsoil upon which the houses in the new town are built, together with a complete absence of precaution to prevent the exhalations from the ground rising up into the houses. ("Our Homes," Cassell and Co., p. 35.) I have now probably said sufficient to prove to you the importance of the subject, and, above all, the necessity of good drainage, and of some means of preventing ground air from penetrating into houses.



# DRAINING AND SEWERING.

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THE terms draining and sewerage are used somewhat uncertainly and even interchangeably by many writers; but I take their proper definitions to be that draining is the carrying away of comparatively clean surface water and surplus water from wet ground, and sewerage is the carrying away of liquid refuse, or sewage.

Many districts have ample natural drainage by porous subsoil, such as gravel, sand, or loose shale, through which the surplus water escapes to some lower place, such as a stream or river. Sometimes a porous and naturally well-drained subsoil has a bed of clay over it, and by merely piercing holes through this clay bed the surface soil may be effectually drained.

Most land is so comparatively impervious that it can only be rendered fairly dry and healthy by drains placed not more than ten or twenty yards apart under its whole surface. These drains should not be not less than four feet deep, and may with advantage be six or eight feet deep. Heavy land improves for many years after first being drained, owing to the continued action of the earth worms, which gradually pierce and thereby drain and aerate the soil down to nearly the depth of the drains; and thus in place of a shallow depth of surface soil resting on a hard sodden bed of undrained subsoil, the worms, when aided by deep drainage, transform the subsoil into a moist, well-aired sponge, through which the surplus water escapes freely to the drains, and from which the surface soil will draw moisture during dry weather. Thus, by good deep drainage, a heavy sodden soil may be made fairly dry during wet weather, and yet made more permanently moist during dry

weather, and it will therefore be much more fruitful ; its average temperature will be raised five or ten degrees, and it will become much more healthy both for men and cattle. As a land drain has usually to convey only a very small stream of water, running almost continuously, and being almost free from sand or sediment, it follows that a rough and uneven channel is quite efficient while it lasts, and so in poor moss land it is usual to form a channel of sods of turf, set like tiles over a channel cut at the bottom of an excavated trench ; loose stones are sometimes filled into the trench bottom for the same purpose. The usual plan for draining ordinary fields is to lay tile pipes made of brick clay, each a foot long, from two inches to six inches diameter, and with butt ends, that is, without sockets. The best plan is to use two lines of pipes, one within the other, with overlapping joints, so as to keep out sand, &c., and prevent the pipes getting out of line.

For land draining about a dwelling, or in connection with main sewerage, glazed socketed pipes are most suitable, though they are too costly for field work. As to the degree of slope, or fall, as it is called, requisite in land drains, if they are of good quality, a slope of 1 in 220 or 8 feet per mile is ample, and even turf or loose stone drains will do well at 1 in 110 or 16 feet per mile. In the flat fen districts, the open dikes or drains have only from an inch to a foot fall per mile. The quantity of water flowing from land drains in very wet weather is about three cubic feet per acre per minute.

Turning now to sewerage, with which we dwellers in towns are more interested, the whole requirements are different. Drains have to take in drops of water at every joint along their course, and convey it in an even stream to the outfall, while sewers have to receive their supplies through definite inlets, at irregular times, in large or small quantities at a time ; and they should convey their contents rapidly to their outfall without losing any by the way. The sewage which sewers are required to convey often contains much hot, greasy waste from kitchens, which is liable to set in the pipes when cooled, and thus gradually stop them up. Then some peculiar people try to make their sewers carry away old wigs or bunches of hair, brushes and combs, sponges, flannels, towels, and many other things which will not dissolve in water, and are therefore very liable to accumulate at bends or junctions, and so cause obstructions. If the sewer joints are not watertight, they permit the liquids to escape, and retain all solids whenever

the slightest obstruction occurs, and thus the evil is aggravated until a positive stoppage ensues, the surrounding soil being meantime soaked with foul liquid.

Sanitary engineers have a complicated task in so arranging the sewers of houses that all these difficulties may be overcome, and so that the sewers may be kept as comparatively sweet and harmless as possible. One of the greatest difficulties in this district is to persuade workmen that sewers ought to be positively watertight, and able to stand some pressure of water within them without leaking. The common practice is to joint the socketed pipes with clay, *so that they can be easily taken up when out of order.* When I meet with such a principle as this one, I like to apply it more widely; thus, I would also have clay jointing to plumbers' work, instead of soldering, and clay jointing to our walls instead of mortar or cement; the principle is as soundly applicable to these uses as to sewerage. But the right way is so to construct the sewers that they never will want repairing, and this can best be done by jointing them perfectly watertight with cement of some kind. Great care is required to prevent scraps of cement remaining within the pipes and causing obstructions. The plan I prefer is to use cement formed of one part of good Portland cement to one of sharp, clean sand. A mop or cloth plug, fitted to the size of the pipes, with a handle about three feet long, should be provided. As soon as one pipe is set in place the plug should be thrust into it with its handle projecting; the pipe socket should then be cemented all round inside, the next pipe put over the plug handle into the cemented socket, and firmly bedded in its true position; the cement pointed smoothly round the outside of the joint, and finally the plug drawn out through the new joint, drawing with it any loose cement from within the joint. The plug must then be cleaned and replaced, ready for the next joint, and meantime it serves to keep any loose material from entering the pipes.

Another plan is to put a collar or gasket of rope yarn round the pipe end before pushing it into the socket, then ramming this collar to the end of the socket, so as to prevent any cement getting inside the pipes, and finally pointing the socket all round with cement.

To make really watertight joints in either of these ways, under the surrounding difficulties of a narrow trench, loose wet soil, propping timber and other obstructions, requires considerable skill and constant care, so that a much better class of workman is

required than the odd men or casual labourers, who are often set to do sewerage. One of the risks to which sewers are liable is the breaking of pipes or cement joints by slight movements or sinkings of the ground, and it is well argued in favour of clay jointing that it will yield to such a movement and be as good as ever after it. I would rather say it will be as bad as ever after it; as liable to give way to any pressure from water within the pipes, and as liable to emit sewer gases from the pipes.

A most excellent plan for jointing pipes perfectly watertight, and yet so as to yield to slight settlements of the ground, is by "Stanford's patent joints," of which I have samples here. These pipes have their ends and sockets fitted with collars of a bituminous substance, arranged to fit one within the other, and to form a sort of ball and socket joint, allowing of slight curving of the lines of pipes, or of slight settlements of the ground. By wiping these collars with an oily cloth before putting them together, they are slightly softened, and so make a watertight joint. They are especially useful for rapid work, or in wet ground, where it would be difficult to make good cement joints; but even for ordinary work they would probably prove cheaper than cement jointing by their greater economy of time and by not requiring so much skilled labour.

Where sewers have to pass over quicksand, or very soft ground, they should be encased in concrete, so as to keep them in true position. This can best be done by arranging the timbers used to support the sides of the sewer trench so that a continuous bed of concrete of about a foot thick may be laid below the sewer pipes. This concrete may be made of one part of blue lias lime, or other lime or cement that will set under water, to from four to eight parts of ballast and sand, this ballast consisting of broken bricks or stone, gravel, shingle, cinders, or other clean hard material broken to the size of hen's eggs or less, enough sharp sand being added to fill the chinks among the ballast, and the whole thoroughly mixed with only enough water to completely moisten it throughout. The concrete should be well pressed into the trench; the sewer may then be laid on the flat surface of the fresh concrete; more concrete should then be carefully packed under and around the pipes, so as to form with the under-bed one solid mass. In sewerage through sinking ground over colliery workings, &c., it is sometimes needful to use strong cast iron pipes, with ball and socket joints, but usually Stanford's joints are strong and pliable enough.

All syphon-traps, inlet grids and traps, access shafts, &c., in connection with tile pipe sewers should be supported on wide foundations of concrete, flags, or brickwork, and encased in concrete or brickwork to protect them from breakage or settlement. All sewer junctions should be curved like railway junctions, so as to lead the currents in the right directions without abrupt turns, which cause eddies and loss of speed. Where there is ample fall available, it is well to arrange slight drops or waterfalls in sewer manholes, or other convenient positions, as they tend to break up floating accumulations, and they also facilitate arrangements for flushing the sewers by moveable sluices or stops in the manholes.

In order that sewers for ordinary house refuse may be self-cleansing, that is, not liable to silting up by gradual deposits of heavy or adhesive substances, the speed of flow through them must be not less than about 150 feet per minute, that is  $1\frac{2}{3}$  miles per hour, and therefore it is positively requisite either to give the sewers sufficient fall to attain this speed of flow, or else to provide for cleansing them by frequent flushing, or other special means. Small sewers require more fall than large sewers in inverse proportion to their diameter, in order to give equal speed of flow.

A thoroughly sound and simple rule for arranging the minimum falls for sewers may therefore be given thus—Let every 4-inch sewer have  $\frac{1}{4}$ th inch fall per yard, every 6-inch sewer  $\frac{1}{3}$ th inch, every 9-inch sewer  $\frac{1}{2}$ th inch, and so on, but wherever the levels permit it, let every 4-inch sewer have  $\frac{1}{4}$ th inch fall per foot, and so on.

When sewers of any diameter thus arranged are running half-full or full, their speed of flow will be 144 feet per minute when the above falls are given per yard, and 250 feet per minute when the same falls are given per foot. But when running only one-fourth full, the relative speeds would be reduced about one-fourth, and therefore it is best to make sewers as small as practicable for their work, so that the flow in them may be deep and rapid, instead of shallow and slow. In estimating the sewage flow from large numbers of houses, it is sufficient to provide for about five cubic feet per head of population per day, or rather, say, one cubic foot per head per hour to meet the busy times, and the rainfall discharge from urban districts may be estimated at 30 cubic feet per acre per minute during heavy rainfall. These two discharges—the sewage and the rainfall—should always be kept separate where practicable.

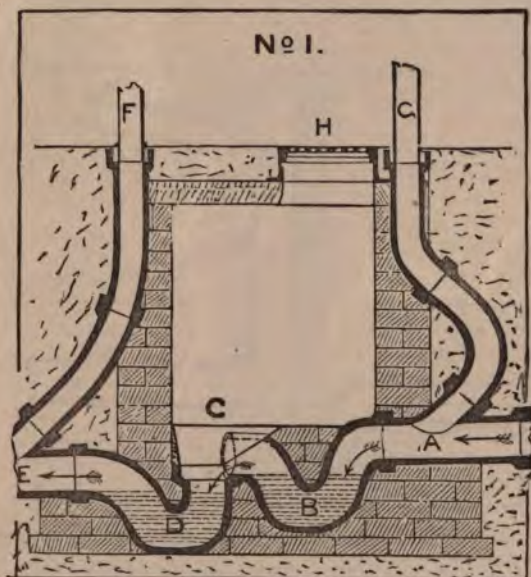
As even the best and most rapidly flowing sewers become slightly coated with putrescible matter, and as their contents are more or less offensive and dangerous to health, the air or gases within all sewers should be rendered comparatively harmless by dilution with fresh air as much as practicable. When sewers are reasonably clean and are amply ventilated, the air from them is not very offensive or injurious; but grids in the roadways cannot, without serious nuisance and danger, be used to ventilate foul and dilapidated sewers, such as most of the old sewers in Manchester and Salford are, to the lasting disgrace of their Health Committees, who are content with pottering about the surface only. The Deansgate sewer is four or five feet in diameter, roughly cut in porous rock: a similar sewer branches into it from near the Old Town Hall. Market Street sewer is badly built of brickwork, and has several times broken in. Most of the minor sewers are of butt-jointed, pointed-oval pipes, thoroughly leaky. I believe that one chief reason why Manchester has remained for very many years in the lowest rank of health (as shown by the death-rate) among all the towns of England is because of the abominable sewers that permeate the whole place with their poisonous emanations. The public of Manchester should take every opportunity of backing-up their officials when they propose important sanitary improvements, instead of apparently preferring high death-rates to increased sewer-rates. The old sewers ought to be used only for surface water, and new watertight sewers should be constructed to collect all liquid refuse, and convey it rapidly and cheaply to the farm lands, where it could be usefully disposed of. Scores of towns in England have now successfully carried out this system, and many Royal Commissions, after examining the various chemical and other alternative processes, have declared the water-carriage system and the land irrigation system to be the only thoroughly efficient and reasonably economical plans for disposing of town sewage.

I cannot in the present lecture spare time for more detailed reference to main sewerage, but must now turn to the details of branch sewerage, serving single dwellings or groups of dwellings.

Every separate dwelling, or group of dwellings, should be only connected with the public main sewers through a syphon trap, which would check the passage of injurious gases or infective germs of disease from the public sewers into the private ones. Thus, each private group of branch sewers would be rendered only

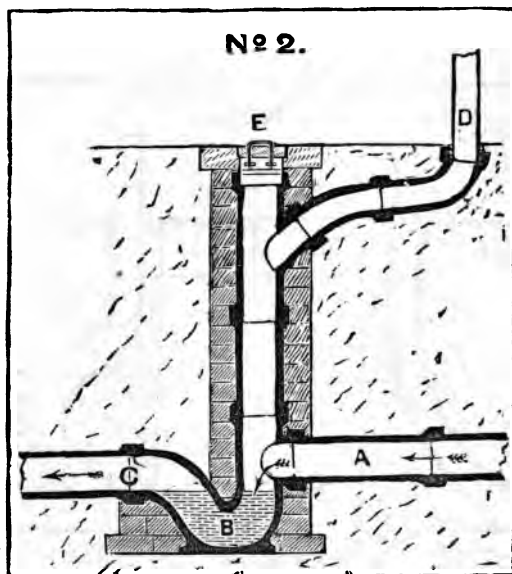
a possible means of spreading infection from within its own area, instead of from any place in the whole town.

The most thoroughly effectual form of intercepting syphons and access manhole is shown in the accompanying section No. 1. The two syphon traps with ventilated open channel between them would effectually guard the house drains from emanations of the public sewers, even if the sewer gases were penned back by a flood or a rising tide.



- A—Private sewer from the house or group of houses. (Sometimes several sewers may be thus brought into one manhole.)  
 B—Inlet syphon-trap, cutting off the house sewer emanations from the manhole, and *vice versa*.  
 C—Open space in manhole for separation of syphon-traps, and for access to them.  
 D—Outlet syphon-trap, cutting off the public sewer emanations from the manhole. (For flushing the sewers a lid is put on to this syphon pipe, with a chain to the surface; water is run into the manhole to one foot depth or more, then suddenly let out by raising the pipe lid by the chain.)  
 E—Outfall to public sewer.  
 F—Ventilator to public sewer, carried up by an iron pipe.  
 G—Ventilator to house sewer, carried up by an iron pipe.  
 H—Iron lid to manhole, for ventilation and access; also forming a reserve vent between the public and private sewers.

A very simple and cheap plan that is good enough for favourable circumstances is also shown in section No. 2. This one trap, with its narrow access shaft and ventilator, could only be completely trusted where the public sewers were reasonably good and well ventilated, but it is of great sanitary value in any case.



- A**—Private sewer from the house or group of houses. (Sometimes several sewers may be thus brought into one shaft.)  
**B**—Syphon-trap, cutting off the public sewer emanations from the private sewer.  
**C**—Outfall to public sewer.  
**D**—Ventilator to private sewer, carried up by an iron pipe.  
**E**—Lid to shaft, for access to the trap by a long rod or scoop.

Every syphon trap should have an access shaft or manhole, for the purpose of removing the before-mentioned brushes, towels, cinders, and other insolubles which are occasionally found in sewers. With proper construction and due care a syphon will keep clear enough, I have seen several that had been buried for a score of years without getting out of order; but after digging down to place the syphon it is always worth while to retain an

access to it, especially as this access shaft permits of easy examination and testing of the working condition of the house sewers. A manhole offers special facilities for sewer flushing, by putting a lid or plug into the outlet pipe, with a chain attached to draw it out from above ground, then running in water to a foot or more in height in the manhole, and suddenly discharging it so as to clear out the outfall sewer.

It is a common fault to make house sewers much too large for their work, even some local authorities having bye-laws stipulating for 9 or 12 inch pipes to single houses. These large sewers almost always get gradually silted up, because the water passing through them is utterly inadequate to flush them; for instance, the discharge from a water-closet is about two gallons, which would one-quarter fill a 9-inch pipe for only one yard length, or the discharge from a bath, passing as it usually does through an outlet equal to a 1-inch pipe, could only fill about one-twentieth of a 9-inch pipe laid with a good fall.

It is not convenient to use tile pipes of less than 4 inches diameter, because of their fragility and the difficulty in jointing them watertight; but it is seldom desirable to use any larger pipe than 4 inches for a single house, and 6 inches will suffice for both sewage and rainfall of the largest mansion or for a group of, say, twenty small houses occupying an acre of ground, as it could discharge 28 cubic feet per minute by a fall of  $\frac{1}{8}$ -inch per yard.

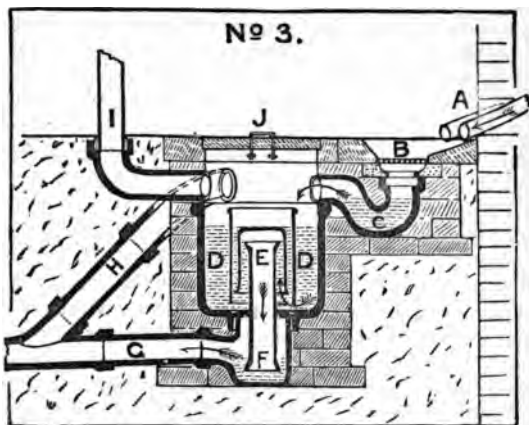
Every inlet to a pipe should have a grid or other guard, with openings less than the diameter of the pipe, so that anything that passes the openings may also pass readily through and out of the pipe. All forms of iron traps are objectionable from the liability to frost, from their rough surface retaining dirt, and usually from their having too narrow water-ways and too little depth of water-eal to their traps. They are also difficult to fix airtight to the sewers, their rusting causing them to break their joints.

In selecting grids and traps (called in this district "gullies") for receiving waste from sinks, lavatories, &c., it is best not to have much space in them to contain filth, but rather to have their capacity small, so as to either rinse out automatically, or to require frequent clearing out whenever much sediment is put into them.

In providing grids for gravel walks, or sometimes for washings from floors, &c., where much scouring sand is used, larger receptacles are admissible; but if frequent clearing out can be provided for, it is best to avoid any such receptacles for putrefying filth on

the premises. Gullies to receive bath or sink waste should have large dishstones and large grids, to avoid liability to frequent stoppage by scraps, leaves, &c., deposited on the grid (see section No. 3).

In some large kitchens, especially where the cooks are wasteful, so much grease and melted fat is discharged from the sinks, &c., that special means must be provided to prevent its choking the sewers when cooled, and so hardened in them.



- A—Waste-pipes for scullery sinks, soup boilers, &c.  
 B—Dish-stone and large iron grid to receive waste.  
 C—Syphon-trap of 4-inch pipe, leading into grease-trap.  
 D—Grease-trap and flushing-tank, holding 12 gallons or more.  
 E—Self-discharging annular syphon and deep-dip pipe, which suddenly discharges the contents of the tank on their reaching the height shown in the section  
 F—Outfall pipe to sewer.  
 G—Ventilating pipe from outfall sewer; also forming an overflow when the tank is not duly cleared of its accumulated bulk of grease, &c., intercepted from the waste water.  
 H—Ventilator to tank, for which a roof-water pipe may be used, thus adding flushing water.  
 I—Lid of tank, for clearing out the intercepted grease.  
 J—N.B.—This apparatus when supplied with fairly clean water, say from a lavatory, forms an effectual automatic sewer-flushing tank.

I think the best appliance for this purpose (though there are other very similar ones) is "Doulton's self-acting grease trap and flushing tank." This simple apparatus, which I show in section No. 3, can be used either to directly receive the discharge from the waste pipe, or preferably a small tile syphon trap may be inserted, as shown, so that no smell from the collected grease can

escape except by the vent pipe, which may often be also a roof-water pipe to aid in flushing the sewer. The effect of the combined syphons on the outlet pipe is to suddenly discharge the fluid contents of the tank as soon as they reach the proper height, the floating hardened mass of grease remains at the top of the tank gradually accumulating, and it can be removed periodically by lifting out a wire basket or by scooping it out.

This form of flushing tank, omitting the grease collectors and supplying it with water from a lavatory or other fairly clean source, forms an excellent means for frequently flushing out a house drain; but wherever a bath is in frequent use, I much prefer to have it fitted with a 3-inch plug and 2-inch waste pipe, so that the bath itself forms an effectual flushing tank, discharging its contents suddenly into the sewer. Such flushing is of great advantage to even the best sewers, and will often enable inferior sewers to serve tolerably well.

I have already mentioned the importance of thorough ventilation of all main sewers, by arranging for air currents through them from end to end, in order to dilute and render harmless their emanations. House sewers even more urgently need through ventilation, yet unfortunately this truth was not generally recognised till very recently, so almost every house with its sewers and waste-pipes remaining as put in twenty years ago or more, has no means whatever of sewer ventilation. The consequence is that its sewer emanations concentrate within its sewers, become more dangerous by stagnation, and presently may escape through defective joints, or even through syphon traps, into the dwelling.

Some sanitarians advocate a sort of open sewer system, in which ample ventilation is provided by totally avoiding syphon traps within the premises, and making all soil pipes and sewers in short lengths with open ends. This plan may be healthy, and it is said that such free exposure and ventilation of the sewage causes no nuisance; but common observation will prove that as each gallon of fluid refuse or sewage has more or less offensive odour, and as time renders it more and more offensive until totally decomposed and changed in condition, the only way of completely avoiding nuisance from sewer ventilation is to effect it by pipes carried up to above the house roof, or in open spaces carried up above head height. The water-closet soil pipe usually forms one effectual vent from or into the house sewers, if it be properly carried up to above the roof with pipes of at least three inches diameter. In many cases

where there is no second soil pipe available a roof water-pipe can be safely used to form the couple, or pair of pipes, needful for ventilating a sewer, one acting as inlet and the other as outlet; but if such a roof pipe is too near a window or near open slating, allowing draught from it into the house, it is not suitable for sewer ventilation.

We must needs remember that the currents in open pipes do not (as some imagine) always tend to rise, for if, when warmed by the sun, these pipes induce an up-draught, they will, when cooled by wind and rain, equally induce a down-draught, and a discharge of water down a pipe causes a powerful down-draught, so we must arrange all our vent pipe ends so that they cannot cause nuisance.

In arranging the sewers of a dwelling they should be, whenever possible, entirely outside the building; only the water-closet soil pipe forming a direct communication between the inside of the house and the house sewers. The cellars should never have sewer grids in them, but their floors should be sloped so as to make all water flow from them into a sunken area outside the house, in which area a grid and tile syphon trap should be placed to convey this waste water into the sewers. This open area should be roomy enough to allow free circulation of air within it, and to permit ready access for cleaning the grid and trap. Some of our local authorities have adopted a ridiculous travestie of this open area system by making so-called "areas" about 18 inches square and six or eight feet deep, with a grid over their top and a door from their base into the cellar. These arrangements are but little better than having the grids actually within the cellars, for any emanations from the grid would be drawn almost entirely into the cellars.

In cases where it is absolutely necessary to have a grid and trap within a cellar, a second trap with intervening ventilation should be placed on the branch sewer from this internal trap at some point outside the house.

Where sewers or soil pipes have to be carried inside dwellings, they should be specially strongly constructed, carefully ventilated, and detached from the main sewers. Thick cast-iron pipes, rust jointed, like town's-water pipes, are often the best for this purpose, being very strong and not liable to rust; only a thin greasy film forming inside the pipes. Tile pipes bedded and jointed with cement may also be safely used. Lead pipes cannot be depended

on; rats will gnaw holes through them; chloride of lime, sometimes used as a disinfectant, will rapidly destroy the upper parts of lead pipes, and in many other ways soft lead is easily pierced and so made dangerous.

As to the use or repair of defective old sewers, it is nearly always the only effectual course, and at the same time the cheapest course, to thoroughly clear away the old sewers and put good new sewers in their stead. Any soaked, and therefore foul earth, around the old sewers near the house, should be removed and replaced with clean earth.

I make no attempt to show plans for arranging the sewers of a house, as the special circumstances of each case have to be considered in arranging such plans, my endeavour being to explain such technicalities of sewerage as practical workmen should understand and carry out in their work.

In concluding this short lecture on a subject of great extent, complication, and variety, I wish to lay special stress on the vital importance of good sewerage. It is now a generally accepted belief that typhus fever may be truly called sewer gas fever, and diphtheria sewer gas sore throat; also that the whole range of this class of diseases, right down to measles, scarlatina, and sore throat, are most frequently induced, if not positively originated, by continued exposure to sewer emanations. With these facts before us, we ought, one and all who have practically to do with sewerage, to bear constantly in mind while at work that the life and energy, and thus the prosperity and happiness of those around us, depend constantly to a most serious extent on the soundness of our work.



# PLANS AND SECTIONS.

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THE scheme of lectures for this winter has been arranged to include many subjects more or less directly connected with house construction and sanitation. Already the important question of site has been fully discussed, and more recently the principles and practice of draining and sewerage. This evening it falls to me to tell you something about plans and sections, not indeed with a view to enabling you to plan dwellings for yourselves, but that you may examine and study a design for a house intelligently, compare one with another, and judge how far the requirements of health, comfort, and convenience are fulfilled. I have seen houses built by working men without the intervention of an architect, but the designs had been copied wholly or in part from others, and the results were not satisfactory. Architectural designing is an art that, like other arts, is slowly acquired, and proficiency in which is only attained by practice. Much skill and knowledge is also necessary in selecting materials for even the humblest dwelling. The materials should, of course, be good of their kind, and as far as possible obtainable in the vicinity, so that the capital invested may return a fair interest, with sufficient margin for repairs, painting, &c. All needless expense should be avoided, but building without an architect is no true economy.

There is, perhaps, no better way for a working man to familiarize himself with plans and sections than for him to measure up the house in which he lives, and draw a plan and section of it to scale. Any intelligent man can measure his room for a carpet, or the walls to ascertain the amount of paper-hanging he requires. Measuring

up a small house is almost as simple a matter, and a very little practice will enable a man to sketch his house in miniature from the measurements taken.

Plans, sections, and elevations are the names given to certain mechanical drawings which the architect projects, and by means of which he indicates to his clients, the builders and others, the form, size, and arrangement of the erection he has devised. A section (from an old word signifying to cut) is a representation of the appearance a building would present if cut asunder vertically—that is, from above downwards. A plan is a representation of the appearance a building would present if cut asunder horizontally—that is, on a plain—or viewed from a point over the centre of the roof. An elevation is a representation of the front, back, or side of a building. Plans, sections, and elevations are not drawn to represent objects as they appear to the eye, the portions near the eye being larger than those remote from it; but the drawings show every object in the flat—that is, put in to one scale. It will thus be seen that to show a house completely there will ordinarily be required several plans (one for the basement, one for each floor, and one for the roof), two sections (one from front to back and one from side to side), and four elevations. However, in dealing with the class of buildings which is to occupy our attention to-night—workmen's dwellings—it will be found, I think, that a front elevation, a section, and one or two plans will show a design with sufficient clearness. As regards size, for a class-room or lecture-room one inch to a foot is a good convenient scale to work to, for deposit plans or book illustrations  $\frac{1}{8}$  inch to a foot or less is commonly sufficient. Plans and sections when completed should show everything about a house, *i.e.*, flues, ventilators, water service, cisterns, waste-pipes, soil-pipes, drains, &c., as from them the working drawings are prepared, and the architect is of course responsible for every detail of his design being efficiently carried out.

I pass on now to the question—What are the requirements of a wholesome dwelling in which men, women, and children can live with self-respect, and enjoy such privacy and comfort as decent people have a right to? Briefly, I would say it is essential that every dwelling-house should be built of sound material on a clean foundation; that it be dry, warm, ventilated, well lighted, and drained; that it have a pure water supply and sufficient sanitary accommodation; that its chimneys draw properly, and that its

rooms be large enough to afford adequate air-space to the inmates. The essential requirements of a workman's dwelling are the same as in all other dwellings, only the accommodation provided for each person has to be more restricted. Even so-called luxuries, such as the clothes-boiler and the bath, are as necessary to the workman as to others, and if we cannot find room for them in each house we should provide them in the near vicinity.

Many of these requirements have been treated of, or will be, by other lecturers who are taking part in this course. I propose, therefore, without further preface, to proceed at once to the examination of the mechanical drawings I have prepared in illustration of my subject. The drawings are arranged in three groups, that is to say—1, designs for country cottages; 2, designs for town cottages; 3, designs for tenement houses. The first group includes four designs, each shown by a front elevation, plan, and section. The set marked "A" shows a cottage of the simplest description, suited to a single working-man or woman, or a married couple without children or lodger. The accommodation consists of a living-room, which is also the kitchen, a bedroom, a wash-house, a fuel store, and detached ash closet. The set marked "B" shows a cottage having similar accommodation, with the addition of an extra bedroom. It would be suited to a couple with two or three children of the same sex or a lodger. The set "C" shows a cottage similar to the first, with the addition of two extra bedrooms. Here the clothes-boiler is in a corner of the kitchen, a usual but not advisable arrangement. This cottage would be suited to a couple with children of both sexes. These three designs are for semi-detached cottages, a saving of perhaps 15 per cent in cost being effected by building in pairs under one roof. The set "D" shows a detached cottage, the accommodation being similar to that provided in set "C," the rooms, however, being larger and higher, and including a washhouse. The walls of A, B, and C are of brick, nine inches (the length of a brick) thick; the walls of D are of rough stone (the bedding surfaces being dressed), equal strength being obtained by making them one-third thicker—twelve inches. The roofs are of slate or red tiles. Time was when rural cottages were commonly formed of clay and straw (cob building) or loamy gravel rammed down hard in the *Pisé* manner, and the roofs formed of combustible materials. Now, however, the approved practice is to construct country houses of the same materials as town houses—bricks, stone, or concrete blocks.

Let me then consider these designs in detail ; but before doing so, I desire expressly to state that they are not put forward as model designs in every sense—that is, as affording the maximum of sanitary advantage for the minimum of cost. I show them simply as examples of rural cottages, varying in size and accommodation, and illustrating some points in construction, to which I ask your attention.

First, as to the walls. The sections show at the bases a widening out of the brickwork, technically termed the footings. The rule is that the depth should be not less than two-thirds of the width of the wall, and that the bottom should be twice as wide as the wall. The footings should rest on solid ground, or stone or cement concrete. It will be seen that although the enclosing and cross walls of the first three cottages are all nine inches thick, they are each constructed in a different way. In the first the wall is solid, bonded in the usual (Flemish) way ; in the second the wall is hollow, the bricks above the footings being set on edge, headers and stretchers alternating in each course ; while in the third the wall is made of courses of headers laid flat, alternating with courses of stretchers set on edge end to end, leaving horizontal tunnels in the centre of the wall. The second method saves one-fourth of the bricks which would be used in a solid wall ; the third method saves one-fifth. Elevations, as well as sections of these walls, are shown. Walls thus hollow or tunnelled are not only more economical and lighter than solid walls, but they are dryer, less easily penetrated by heat or cold, and for all practical purposes as strong as solid walls. In party-walls the hollow is useful in acting as a check to the passage of sound. Notice that in all the walls a damp-proof course is shown. This may be made of sheet lead or asphalte, slates laid in cement or anything impervious to moisture, and should be about six inches above the level of the adjoining ground.

Next, as to floors. The first, as you will see in the section, consists of six inches of cement concrete tiled over. The second has a three-inch foundation of clean, dry ground, and on this three inches of asphalte, the surface being carefully finished with small stones, making a hard smooth top. The third has a floor of wood blocks. A foundation of broken rock or bricks, or clinkers or other dry material, is put in and rammed. This is covered with asphalted cloth, on which are placed the blocks, three inches thick, the section forming the tread being across the

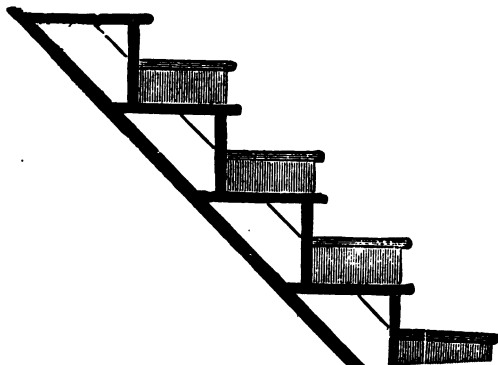
grain of the wood. Comparing these three floors together, it may be said that the tile makes the cleanest floor, the asphalt the driest, and the wood blocks the warmest. There are many other floors in use in cottages—lime ash floors, brick floors, concrete block floors, for instance, all cheaper than those I have referred to, but not as satisfactory. The best floor of all is provided in the stone cottage—planks carefully tongued and grooved, on joists resting on hard wood sleepers. The joist-ends and the planks next the wall are separated from it by a thin layer of cement. Under the joists is an air-space six inches deep, and this is thoroughly ventilated by holes through the thickness of all the external walls, protected by gratings.

I come now to windows. Every habitable room should have at least one window opening directly into the external air. In order that the room should be sufficiently lighted, the area of the window or windows, clear of the sash frames, should be equal to at least one-tenth of the floor area of the room. Apply this rule to cottage "A," the kitchen is 14 feet  $\times$  10 feet, the window 4 feet  $\times$  5 feet, therefore the window area is one-seventh the floor area; the bedroom is 11 feet  $\times$  10 feet, its two windows together 4 feet  $\times$  3½ feet, therefore the window area is about one-eighth the floor area. Another rule about windows is that one-half at least should be made to open, and the opening should extend to the top of the window. The way cottage windows are ordinarily planned to open, that is, like a door, is objectionable. Sash-windows sliding up and down are far better, or the sashes may be swung on pivots, which is an efficient method. Windows should not be placed too low down, not less, I think, than 2½ feet from the floor, and should, where practicable, extend nearly up to the ceiling. Though windows should be placed in position to afford a ready means of ventilating rooms, they must not be relied on as the sole means of ventilation.

This brings me to the question of the size of rooms. No habitable room should be of less height than 8 feet, or have a floor space of less than 64 square feet. Occasionally, where a height of 10 feet can be given, a floor space of 50 square feet may suffice, but only when thorough ventilation is provided for. In no case should a habitable room contain less than 500 cubic feet of air-space, or a double-bed room less than 1,000 cubic feet air-space. In most of the rooms in the rural cottages I am commenting on, this air-space is much exceeded. In planning rooms,

the most convenient proportion ordinarily is that the width and length should be in the proportion of 3 to 4.

A word now on stairs. These are usually made of wood, and the substitutes proposed—iron, tile, &c.—are heavier and dearer, and more dangerous to children who may fall on them. A staircase should never be less than two feet broad. The tread should extend forward at least one-third more than the height of the riser. Where 3 feet is available for the width of the stairs, and there is yet so little space forward that the riser would have to be disproportionately high, each step may be made to rise in two heights. In plan of cottage "C" such a staircase is shown. The stairs have an ascent of 9 feet in 9 feet, the whole staircase being at an angle of 45 degrees. Thus, though in each half the rise is about 10



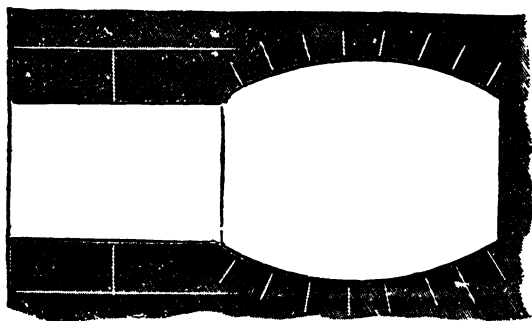
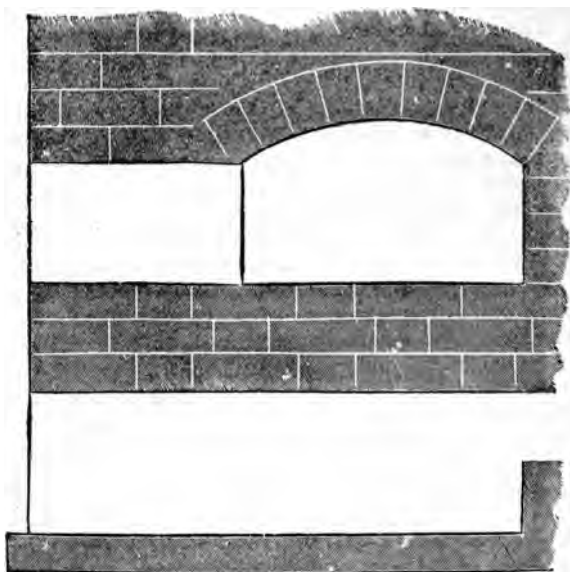
Section of Staircase

inches, the actual step up is only 5 inches. A section of this staircase is given. It is lighted by a window from the side.

The various regulations which have been made from time to time as regards the construction of fire-places, flues, and chimneys are almost entirely with reference to structural safety and the avoidance of danger from fire. Chimneys or flues built from the basement should rest on footings and have solid foundations. Other chimneys or flues should be built on sufficient corbels of incombustible material. All chimneys or flues must be properly bonded into the wall against which they are built, and the inside should be properly rendered or pargeted as the work is carried up,

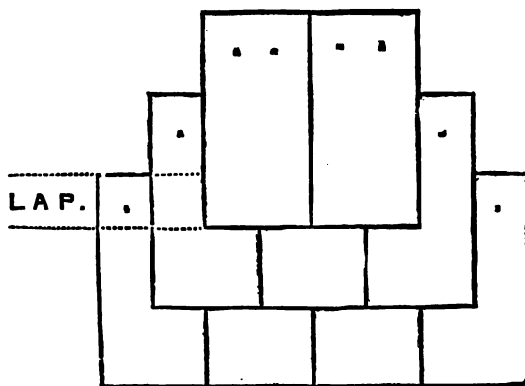
except where fireproof piping is used as a lining, and the angles are filled in solid with incombustible material. Every chimney-breast should be supported with an arch of brick or stone or bar of iron. The chimney jambs should be not less than 9 inches wide on each side. The walls of every chimney or flue should be at least  $4\frac{1}{2}$  inches thick, and if it be necessary to give it a sharp turn, the upper side should be 9 inches thick. The chimney should be carried up to a height of not less than 2 feet above the roof, if it pierces the roof at the ridge; in any case it should be carried up higher than the ridge, and, if necessary, secured with a tie. Where the chimney pierces the roof, it is well to insert a damp course. No timber or wood work should be allowed in any chimney, breast, or flue, or immediately under any hearth. No openings for any ventilating valve or other purposes should be within 9 inches of any combustible material. No pipe-flue of iron or otherwise should be less than 9 inches from any combustible material. As a general rule, it may be said that chimney-flues should be carried up inside walls in preference to outside walls, and that they draw better when two or three are placed together. In rural cottages it is often a great convenience to provide a small oven. A space of about 3 feet  $\times$  2 feet will be found sufficient for the purpose. A plan and section of one is submitted.

Finally, as regards the roof. Here the desiderata are that the framework shall be strong enough to bear the weight of the covering it is designed to support, together with a reasonable amount of snow, and that the covering material shall be impervious to wet, carry off the rain readily, and be so securely fastened that no part shall be loose or become displaced. It is convenient, also, if practicable, to introduce a non-conductor into roofing, making the house cooler in summer and warmer in winter. The roof frame is of wood, rarely iron, and the covering is slates or tiles, or thin pieces of stone, sheet lead, corrugated iron, &c. If the covering is to be slate, the inclination should be not less than 26 degrees; if tiles or thin stone, the inclination should be not less than 30 degrees. If the roof is to be covered with metal a very slight slope will suffice. Three of the cottages illustrating my subject are slated; one is tiled. Tiles are made of baked clay, like bricks, and usually measure from about 14 inches  $\times$  10 inches to 10 inches  $\times$  6 inches, and  $\frac{1}{2}$  to  $\frac{1}{4}$  of an inch thick. They are plain, corrugated, or simply curved like the letter S from side to side. In cottage "B" the latter are shown. These tiles are not pinned to



Section and Plan of Oven.

the laths, but hung on them by a little projection at the back, and overlap one another laterally. Slates are cut to various sizes, generally being twice as long as broad—for cottages, usually 12 inches  $\times$  6 inches, or 14 inches  $\times$  7 inches; for larger houses, usually 20 inches  $\times$  10 inches. The thickness is from one-sixth to one-eighth of an inch. The best way of laying slates is on boarding covered with felt. However, in cottages the slates are usually laid merely on laths. They are fastened to the wood by nails, which should be of some metal other than iron, and (except when boarding is used) the under side of the slates should be pointed with mortar. Each row of slates should overlap the top of the row next but one below them by three inches, and each



Sketch showing Lap.

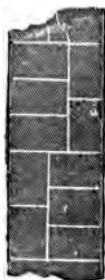
slate should be laid immediately over the line between the two slates beneath it. See sketch. Hip and ridging tiles may be used for slated as well as tiled roofs, the jointing being carefully made with cement. The flashing round the chimneys, &c., should be of zinc or lead. Cement is not suited for the purpose, as it cracks away from the brickwork. Valleys, &c., may be of zinc or lead. Rain gutters and rain pipes may be of iron, and should be designed to stand away two or three inches from the wall. A coat of zinc (galvanizing) will effectually prevent rust.

The cost of these four rural cottages is (exclusive of site) as follows:—A, £130 the pair; B, £210 the pair; C, £290 the pair; D, £170 the cottage.

The second group of designs includes four, each shown by a front elevation, plan or plans, and section. The set marked "E" represents a town dwelling of the smallest description, suited to a single working-man or woman, or a married couple without children or lodger. The accommodation provided is a living room  $14\frac{1}{2}$  feet  $\times$  10 feet, and a bedroom two-thirds this size, a scullery, and a passage leading to it, a w.c. and coal bin, a yard in rear 130 square feet clear, and a neat little porch giving access to the living room. The height of the living room and bedroom is 10 feet. It may be remarked that the bedroom is barely large enough for two adults, but as the occupants would probably sleep with their room door open the available air-space would be increased. The set of drawings marked "F" represents a town dwelling somewhat larger, adapted to a man and wife with a single lodger. The accommodation provided is a living room  $17\frac{1}{2}$  feet  $\times$   $12\frac{1}{2}$  feet, a room for a double bed  $12\frac{1}{2}$  feet  $\times$   $9\frac{1}{2}$  feet, a room for a single bed  $9\frac{1}{2}$  feet  $\times$  7 feet, a w.c., a coal bin, a lumber closet, and a clear yard space of only 77 square feet. The height of the living room and two bedrooms is  $8\frac{1}{2}$  feet. A small lobby is taken out of the living room. Here the front bedroom is barely large enough for two to sleep in, containing something less than 1,000 cubic feet of air-space. The living room, too, is so exceptionally large for a cottage as to suggest that a little might have been spared from it for a scullery. The necessity of putting the sink-stone in the yard would then have been avoided, an arrangement which is specially inconvenient when the yard space is already too limited. Several of each of these small town dwellings have been recently erected at Pimlico, Dublin, and they seem to be appreciated by the tenants. Certainly they are a vast improvement on contiguous dwellings. The space covered by "E," including yard and offices, it will be seen, is 37 feet deep and 15 feet wide. The space covered by "F," including yard and offices, is  $30\frac{1}{2}$  feet deep and  $13\frac{1}{2}$  feet wide. The cost of "E" was £75, the cost of "F" was £110. In the plan of the two-room dwelling (E) you will notice that the front and back walls are only 8 inches thick. Such a wall is made by backing bricks laid flat with bricks on edge—that is, three bricks are built up and by their side are built two bricks on edge, and then this arrangement of five bricks is reversed. A portion of a section of a wall

thus built is shown. The party-wall in the same plan is shown 6 inches thick. This is made by building bricks on edge side by side. Considering the height of the front wall of house "E" is only 9 feet, an 8-inch wall is sufficient for safety, and the method of construction shown makes a fairly secure wall. A 6-inch wall, unless tied together in some way, is little better than a  $4\frac{1}{2}$ -inch one. Of course walls 8-inch or 6-inch thick may be built of bricks made to a special size, and then the walls can be as firmly bonded as a 9-inch wall. Neither of these dwellings are furnished with ashpits, as the ashes from each cottage are put into a bucket and collected daily.

The set of drawings marked "G" shows a town workman's dwelling, suited to a man and wife with children of both sexes. The accommodation comprises a living room 12 feet  $\times$  11 $\frac{1}{2}$  feet, and a



Section showing Wall.

front room 11 feet  $\times$  11 feet on the ground floor, and two bedrooms of corresponding sizes on the floor above. There is a 3-feet passage leading past the front room to the living room and staircase, a basement room, which might be used as a washhouse, a scullery, closet, and ashpit, and a yard of 105 square feet clear. Each of the four rooms is provided with a fireplace, and all have a clear height of 9 feet. There is an attic also, which might serve as a lumber closet. The cost, exclusive of cost of site, enables these dwellings to be sold at £170.

The last of the four designs for small town dwellings, marked "H," shows a house suited to a clerk or foreman earning good wages. It provides a parlour 12 feet  $\times$  12 feet, a basement wash-house of the same size, a kitchen 13 feet  $\times$  12 $\frac{1}{2}$  feet, two bedrooms

on the floor above, and a bedroom and attic on the top storey. There is a passage  $3\frac{1}{2}$  feet wide leading to the kitchen and stairs, a scullery, closet, and ashpit, and a yard of 84 square feet clear. Each of the six rooms has a fireplace. The rooms on the parlour floor and next floor have a clear height of  $9\frac{1}{2}$  feet, and the top back bedroom is  $8\frac{1}{2}$  feet high. These drawings represent the small houses recently erected in Goldsmith Street. The cost per house is £260. The designs "G" and "H" are the Oddfellows' Co-operative Building and Investment Company's. The object of the company is to provide good substantial property, having proper sanitary appliances, adapted to the requirements and means of clerks, artisans, and labourers, and to enable the tenants to purchase the houses by easy instalments. The houses referred to here appear to be conveniently arranged, the only defect worth mentioning being the deficiency of yard space. But even in this particular they compare favourably with many larger and higher houses in this town.

The remarks I have made on construction when speaking of country cottages are equally applicable to town dwellings. A town house no less than a rural one, must be built of sound materials and on a clean foundation, and must be dry, well lighted, warmed, ventilated, and drained. It is true, also, that many of these essentials are far more difficult to secure in the town than in the country. The foundation is far more likely to be foul, and will require special attention; mortar made with anything but good lime and clean sand is far more likely to be used, and it may be necessary to see that old bricks from condemned insanitary property are not smuggled into party-walls and inside walls. Then, whereas in most country districts the most suitable sanitary accommodation for the cottage is an earth-closet or ash-closet, in towns the best accommodation is usually the w.c., with separate service cistern. In particular, I may observe that in planning town houses special precautions have to be taken to secure sufficient air-space about the buildings, and to prevent damp and the spread of fire. As regards the first matter, the model bye-laws require that every new domestic building shall have an open space in front, measured to the boundary of the premises immediately opposite, throughout the whole line of frontage of 24 feet at least, such distance being measured at right angles to the frontage. The requirement as to the rear is that every new domestic building shall have an open space exclusively belonging to such building free from

any erection thereon above the ground except a closet and ashpit ; and that such space shall extend, laterally, throughout the entire width of the building to a distance of from 10 feet to 25 feet, according to the height of the building, and that in no case shall the aggregate extent be of less than 150 square feet. These appear to me quite reasonable requirements. Inasmuch as town houses often have a sunk storey it follows that the ordinary damp-course already described is insufficient. The method adopted in better class houses to keep out the damp is to clear the ground away from the sunk or half-sunk storey, and form an area to a depth somewhat below the level of the basement. When, as is ordinarily the case in small houses, there is not room for this, an extra wall may be built from the footings to the ground level,  $1\frac{1}{2}$  or 2 inches from the wall, and the space between covered, ventilated, and drained, or the portion of the wall below the ground level may be built hollow and with two damp-courses, one above the footings at the bottom of the hollow and another above the ground level at the top of the hollow, provision being made for draining and ventilating the hollow ; or the outside of the wall below the ground level may be coated with cement asphalted over. As regards the third matter, there is obviously much greater risk of fire spreading when houses are built in terraces or rows than when detached or semi-detached. Special care should be taken that the back of chimney openings in a party-wall be thick enough, and well rendered over, especially kitchen chimney openings ; that no wooden plugs get knocked into the flues ; that there be no openings in the party-wall ; that dormer windows, lantern lights, &c., be covered with incombustible material. It is recommended, also, as affording additional safety, to carry up the party-wall through the roof to a height of not less than one foot. Of course the top should be provided with a stone coping, or other device to conduct off the rain water, and at the point where the wall joins the roof, flashing should be fixed.

Of late years blocks of tenement houses have been erected in many large towns. Many such buildings have been the outcome of charitable trusts, rarely they have been provided by municipal authorities, and not a few are the result of the enterprise of private companies. It is to be regretted that, as a rule, such enterprise has not been more successful financially, but this is due to commercial depression and the extravagant price of town sites in convenient central positions, &c., and certainly not to want of

appreciation of the accommodation provided on the part of working men. I believe one of the earliest attempts to provide working men with comfortable dwellings in large tenement blocks was made in my own town of Birkenhead. There, upwards of a third of a century ago, eleven blocks were erected on a triangular site near the Great Float. Each block is carried up three storeys above the ground floor, and the number of separate dwellings provided is 324. All are three-room cottages with sculleries, two only excepted, these having four rooms each. They let fairly well at prices varying from 2s. 3d. to 4s. per week each, the tenants being well behaved and orderly. The accommodation in these three-room cottages consists of a living room 14 feet  $\times$  10 feet, and two bedrooms, together measuring 14 feet  $\times$  12 feet, a scullery about 5 feet  $\times$  3 feet, and a small closet. Each cottage is adapted for a married couple and one lodger, or not more than two very young children. I am not showing a plan and section of these dwellings, as they have defects common to most tenements planned by the last generation of architects. The closets open into bedrooms, and are not built out from the enclosing wall, the sculleries are not against an external wall, and ill-lighted, and the staircases are not sufficiently ventilated. In certain respects an improvement on these are the tenement houses provided by the Corporation of Liverpool in 1869. They are known as St. Martin's Cottages, and consist of 146 separate dwellings. The accommodation in each dwelling is a living room and scullery, with one, two or three bedrooms, and the price charged ranges from 3s. 6d. to 6s. 6d. per week. Houses of three sizes being provided is an advantage, and so is the ventilation secured by open landings. However, four of the six blocks have cellar floors, which even when clean and dry do not make comfortable separate dwellings, and the rent charged for even the smallest dwellings is beyond what many labourers can pay.

The tenement dwellings shown in the elevation, plan and section marked "I," will be doubtless easily recognised by many present as representing the workmen's houses recently erected at Holt Town. There are two small blocks, each having two storeys above the ground floor. The block facing Medlock Street provides twelve small dwellings, and the block facing Cyrus Street fifteen small dwellings. The plan, elevation, and section show half of the block in Medlock Street. It will be seen the dwelling consists of a living room 12 feet  $\times$  12 feet, and a bedroom 12 feet  $\times$  10½

feet, a closet, ashpit, sink, and coal bunker. The height of the storeys from floor to ceiling is 9 feet, the top storeys being 3-inch higher to compensate for space occupied by roof eaves. Here the sanitary accommodation is sufficient, the ventilation of the stair-cases and landings is fairly good, the living room is large enough, but the bedroom, though divided off into two compartments by a screen, is really only large enough for a married couple without children, the air-space being 1,134 cubic feet. Between the blocks is a drying ground measuring about 70 feet  $\times$  60 feet, which is a great convenience, and furnishes the means of ventilating the back premises.

The plan and section marked "J" illustrates a good example of tenement house adapted to suit the requirements of single working men, small or large families. It represents a portion of a block in Cartwright Street, London, erected under the auspices of the East End Dwellings Company. The height of the building from the ground to the roof eaves is 45 feet, the height of the rooms from floor to ceiling being  $8\frac{1}{4}$  feet. The arrangement of the ground floor and the four floors above it corresponds. The size of the portion of each block accessible by a common stair is about 92 feet  $\times$  30 feet. The arrangement of half a flat is shown on the plan, the other half is similar but reversed. Thus it will be seen that in a space containing 2,760 square feet there are 14 rooms, a staircase, six closets, and two sinks. The four rooms in the centre are approached direct from the stairs, the five rooms at each end by means of a balcony. The floor is so planned that ten of the fourteen rooms may be let off separately, or two, three, four, or five may be let together. Each room has a window looking to the front or back, a fire-place, and space for a 6-feet bed. The closets are placed together and in the best position to ensure ventilation. Such dwellings may of course be continued without break along a street of considerable length. Four of the rooms in each floor—two containing about 690 cubic feet and two about 620 cubic feet of air-space—appear too small to be occupied by single men as living and sleeping rooms, but such men commonly take all their meals at coffee-rooms or eating-houses. The dwellings seem to me compact, and on the whole well designed.

The plan and elevation marked "K" is a design for a model house for working people, for erection on a New York town lot measuring 25 feet  $\times$  100 feet. It will be seen that the space covered by the building is only 25 feet  $\times$  84 feet, a yard 16 feet

deep being left in the rear. There are five flats, and each flat is divided off into four separate tenements—two in front and two behind—each 38 feet deep. In the centre is the common staircase, on either side of which is an open court. On each landing are two closets, built out into the court on one side. Each separate tenement comprises three rooms, varying in size from 12 feet  $\times$  11 feet to 10 feet  $\times$   $6\frac{3}{4}$  feet. This design is well worth study. With it I submit for your careful consideration a selection of original plans for model tenement houses which were sent in competition for the prizes some time since offered by the proprietors of the *Sanitary Engineer*. Many of them are very clever, and well deserving of your best attention. Certainly one of the problems presented—How to secure light and efficient ventilation for houses many storeys high, three times as deep as wide, and placed in a row—is not easily solved. The plans were kindly sent me at my request by Professor Chandler, of the School of Mines, Columbia College. The order in which they are arranged is not in order of merit, but one that appeared to be convenient for purposes of comparison.

The plan and elevation I now draw your attention to is marked "L." It is a design for a large tenement house having a basement and three floors. The building is 88 feet deep and 50 feet wide, and is built round a quadrangle 30 feet square. It is arranged as two distinct houses, the first, second, and third floor in each house containing nine, ten, and ten rooms respectively. The rooms vary in size from 13 feet  $\times$  13 feet to 9 feet  $\times$   $7\frac{1}{2}$  feet. As the building is designed to form one of a row, the windows look to the front or back or into the quadrangle. This design has some obvious defects, as, for instance, the closets being placed right in the interior or against a party-wall. However, the defects in the plan could be easily corrected. The quadrangle and the wide arched entrance to it would furnish a larger supply of air to the building than the arrangement for providing air adopted in design "K."

I have no special observations to make as regards the construction of tenement houses. The rules as to construction of smaller houses hold good. The more people you accommodate on a given space the greater will be the necessity for precautions against foul air, danger from fire, &c. In large tenement houses, too, it is most important to admit daylight to all the rooms and passages, as dark corners are sure to be dirty

corners. The thorough ventilation of every part will also have to be well considered, and no facilities for accumulating refuse should be afforded. The thickness of the wall will have to be regulated in proportion to the height of the building. Rules are given in local bye-laws with reference to this. According to the model bye-laws all buildings exceeding 25 feet in height or 35 feet in length, or comprising more than two storeys, must have 13½-inch walls below the top storey, &c. Each portion of such blocks accessible by a common staircase should be treated as a separate building, having the party-wall intact, and this, as a precaution against fire, should be carried up through the roof.

Before I conclude I should like to add a few words on aspect. In tenement houses there is rarely much choice, the problem presented being mainly how to make the utmost out of the site, and blocks having to be placed parallel with or at right angles to some particular street. Even in small town houses in rows the question of aspect is commonly decided by the position of the street. But in country or suburban cottages an opportunity is frequently afforded of selecting the aspect. What is the best will often depend on the position of the site and environment. However, as a general rule, it is well to have the corners of the house nearly true to the points of the compass. Usually a front directed to the south-east is to be preferred, and the next best is probably a north-west aspect. A north-east front is to be avoided, because it is unduly exposed to cold wind, and a south-west front is objectionable in most cases as exposing to rain. But where it is desired to insure the greatest amount of warmth and light in the front rooms, a south-west aspect should be selected, as being most exposed to the sun. In regard to town dwellings, it is not beyond the truth to say that in nearly all cases where the architect cannot pick an aspect to suit his plan, he can modify his plan to suit the aspect prescribed for him. For instance, in planning small terrace houses for the north-east and south-west side of a street the plan should be varied, a suitable design for one side would not be suitable for the other side. The kitchen and larder, &c., should be on the cool side of the house; the bedrooms, where there is rarely a fire, on the warm side.

It now only remains for me to thank you all for your kind attention. There are some plans and sections here which I have not been able specially to refer to, which I hope you may have time to look at. The examples I have taken in illustration have

been selected as leading up step by step from the smallest rural cottage to the large modern tenement house. I trust I have succeeded in communicating some elementary information about house construction, for it is a subject no householder can afford to be ignorant of.

# FOUNDATIONS AND MATERIALS USED IN BUILDINGS.

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By JOHN HOLDEN, F.R.I.B.A., F.S.I.

*President of the Manchester Society of Architects.*

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THE subject of this paper will, I think, be interesting to all those who are in any way connected with building operations, and I will commence by stating that it is addressed more particularly to the students who are assembled here, although I hope that those who are more advanced in years may gather something from it which may interest and be of use to them.

Many no doubt amongst you, although you may be employed daily in building operations, may not have many opportunities of seeing the actual commencement of the building upon which you may afterwards be engaged, as the foundations are usually got out, and in many cases filled in again, before the general workpeople come upon the ground, with the exception, perhaps, of one or two carpenters, who will be engaged in preparing the first portions of the timbers, such as lintels, joists, centres, &c. Probably few of the students or apprentices will see the building until the work is more advanced or until there is something for them to do, and even should it be your good fortune to be sent to the building at its commencement, probably few of you will give more than a passing thought at the foundations.

Now, I wish to impress upon you that the foundations are the most important part of the building, as they influence the whole of the structure, and should any *failure* take place in this part the *entire structure* suffers. Without such failure can be looked to at once, and the mischief prevented from extending to the superstructure, settlements and cracks will appear which will destroy the beauty of the building, as they can never be properly repaired—or, rather, prevented from showing—and they almost always indicate *defects in the foundations*, for which somebody is responsible.

Dealing with the foundations *mechanically*, I always particularly impress upon the workmen the necessity for beginning properly at the *bottom*; the upper portion of the building can be *seen afterwards*, and dealt with from time to time, but the foundations are soon covered up, and consequently are more difficult to examine should any defect show itself.

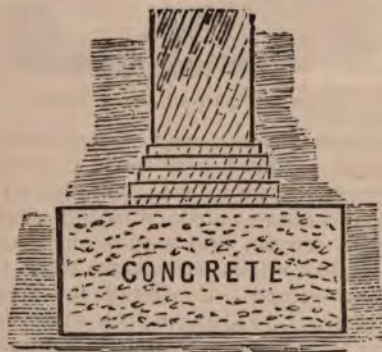
In foundations, as you are aware, many different kinds of material are found, from hard rock to shifting or quicksands, including all the intermediate gradations.

So far as its capability of sustaining the weight is concerned, ordinary rock gives little trouble, at least in the general class of buildings; but even with rock, care is required, more especially if the strata should not be horizontal, as when the weight comes upon it there may be a slide, which will give you some trouble. I would, however, strongly impress upon you the advisability of examining the foundations *yourself*, if the responsibility rests on *you*; *don't take anybody's word for it*. I do not wish you to understand that I consider the workman would intentionally deceive you, but generally, where there is *no responsibility* there is little care, and you should endeavour to depend upon yourself and not upon others. A curious instance of this occurred in my own practice. When the Grosvenor Hotel in this city was commenced, I was requested by the owners to confer with their architects upon any questions of construction, and particularly in respect of the river wall, which they were then commencing. I at once directed my attention particularly to the foundation, which was to be taken down to the sandstone considerably below the bed of the river. When the first length was excavated, the man in charge reported that he had gone down to the rock. I directed him to bore this rock two feet deep in places to see that he had really reached the *solid*; at my next visit he reported that he had done so and found all *solid*. I then asked him to show me the bore holes, the trench being covered some few inches deep with water. He tried about for a short time, but *could not find the holes*. I then told him to get his bar and hammer and to make a hole for my inspection. He did so, and in about half-an-hour his bar slipped into some loose gravel underneath. I had this broken up, and what the man had assumed to be the solid rock turned out to be a shell of a few inches thick, beneath which was gravel and sand about two feet thick, and then the solid sandstone. Of course I had all this removed, and the surface of the sandstone

levelled for the bottom course of the footings. This building, as you are no doubt aware, is a very heavy one, consequently the foundation was of great importance. Now, the foreman had been mistaken in this case, or misled by the labourer whom he had employed to drill the holes. You see, when a man is working in a hole up to his knees in water, he is apt to *manufacture a solid bottom*, if he does not get *at one very quickly*.

The other extreme, quicksands, requires very great care, and, in the first place, judgment must be exercised in interfering with them at all. If the building is a light one, and there is a reasonable amount of fairly solid material above the sand, it may be advisable to leave them alone, and to make a broad and solid footing to the walls, so as to distribute the weight over a large surface of ground. This may either be done by a broad platform of good concrete, or with large flag landings. I have used both.

Some years since I built a chapel on the borders of Carrington Moss, and, as the ground was soft and the bottom was not easily

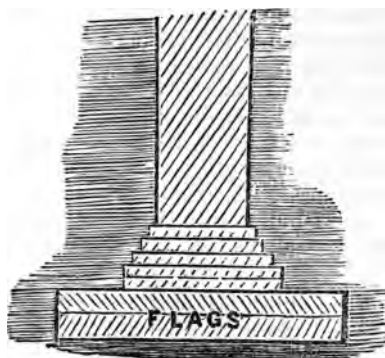


Concrete under walls in soft ground.

reached, it being originally moss land reclaimed, I placed the walls on a broad platform of concrete, about eight or nine feet wide and about three feet thick, spreading the footings out so as to fairly distribute the weight. I am not aware that there is a single crack or settlement in this building, and I asked one of the principals connected with it a few days since.

In a portion of a mill in Salford we used two thicknesses of rough

flag landings, about six feet long, laid crossways, and breaking joints with one another. We knew there was quicksand under, but there was some six feet of good hard made, or partly made, ground above it, and as we had some experience of the cost of going *through*, for the remainder of the mill, we (with our client's consent) adopted this course successfully.



Rough flags under walls in soft ground.

Concrete is, as you are aware, very largely used in and about London in foundations, but I have heard it strongly objected to here, on the ground that brickwork was better; I think this mainly arises from a misapprehension of the manner of using it. If brickwork set in cement were used of the same dimensions as the concrete it would no doubt answer the same purpose, but the cost would be much greater. Concrete is the cheapest material I know of for forming a solid platform upon which to commence the walls, but it must be sufficiently thick in proportion to its width to run no risk of splitting or breaking up when the weight comes on it, otherwise it is useless.

I believe concrete to be a very valuable servant if honestly made of good and proper materials, but a great deal of that now used is simple rubbish.

I have recently, near London, had some foundations opened at a building, where I have been called in, and found a pad of concrete only about twelve inches thick placed under the wall, formed of common lime and gravel, *absolutely useless*.

When you come to consider the cost of putting in foundations of any depth through quicksand, it should be remembered that if such expense can be avoided by other means, a considerable amount may be expended on *these other* means, and still a substantial gain be the result, but with foundations it is not judicious to *economise too closely*, as you must consider the value of the superstructure—I have, as I have said before, had some experience in putting in foundations of this description, where we had to go down twenty-seven feet partly through quicksand before we could obtain a solid foundation; pumps had to be kept going night and day for weeks, and the cost was very great.

As an instance of the want of care in putting in foundations, I refer you to this drawing, in which you will see that an engine bed has been placed directly on some quicksand, which in this district is found very frequently in what are called pot holes or small patches. This was found out by my late father and myself in examining a mill which was said to have been damaged by mining operations underneath. Considerable mischief was undoubtedly done to the building, and some of the machinery was disarranged, amongst others the pusher, or high pressure engine, which had some time before been fixed adjoining the main engine to assist it. The result of our examination led us to conclude that the mischief was not due to mining operations at all, but to inherent defects in the buildings, and to carelessness in dealing with them, as, for instance, in these engine foundations. The curious part of the affair was, however, that the main engine foundation, a few feet to the side, was principally on solid and firm clay, and the main chimney, a few feet towards the end, was also on solid clay, but this particular foundation, being fixed lower down, was right on the quicksand, or, as it was termed in that district, *cow-belly*. Unfortunately for our client, the umpire was a mining engineer, and we could not convince him that this state of things was sufficient to account for the damage, although, after a special examination, these facts were admitted by counsel for the plaintiff.

Clay, particularly, should be carefully examined and drained and protected from the action of water, if used as a foundation for heavy buildings, as when wet, it is liable to give way, and in fact, in all foundations care should be taken to avoid access of water to them, which, by softening the ground underneath, may cause damage.

Now in a sanitary point of view foundations should be carefully

dealt with. You all know that in large cities like London, Manchester, Liverpool, and others there must of necessity be a very large amount of refuse always to be got rid of, and low lands are eagerly sought after to be used as tips. This is all very well so long as the land is in the country and lying idle, but as these tips are generally close to the towns (the closer the better, cartage being a consideration), as soon as the depression is filled up with this rubbish—very often partly nightsoil—the owner finds that his land has been converted into building land and is marketable, and, quite irrespective of the consequences, it is disposed of and built upon. In Manchester the nightsoil is at present dealt with by the Corporation in another manner, so that we must not credit them now with tipping that material; but Harpurhey and Collyhurst are instances of this mode of treatment in former years, and I well remember in 1865 surveying some land in Harpurhey, close to the continuation of Queen's Road. I had several days' work there in settling some boundaries, and the low land at the side of the road was in process of being filled up with nightsoil, road scrapings, and rubbish. The stench was something horrible, and effectually spoiled my appetite for the time. But the opportunity was too good to be lost by the owner of the land, and cottages were built as close to the edge of the tip as was practicable. This part, of course, is now all thickly populated, and we may imagine the state of these houses, built of the lightest materials, with little regard for sanitary arrangements (which in those days were very much worse than they are now), and with not the slightest attempt made to counteract the evils existing *below*. But tenants were plentiful, for poor people are obliged to live close to their work, and must put up with anything in the way of shelter.

Unfortunately our building bye-laws cover the very lightest and cheapest property, and contain no provision for protecting the property from *below*. I have been told that nightsoil and road sweepings make in a few years a very solid mass, as the cinders and sweepings form a sort of concrete which is very solid. This may be so, but for my part I would much rather not have it under my house without there was a good layer of concrete above it which was impervious to both damp and gases. The warmth of the house is certain to draw any gases which are present from the ground. I consider that where land has been filled up in this manner, having been used as a tip, the authorities should not allow any buildings to be placed upon it until the plot has been

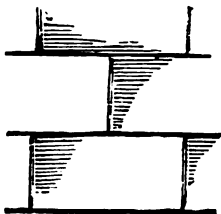
levelled and a layer of good concrete twelve to eighteen inches thick formed over the entire surface intended to be covered by buildings. No doubt the landowners would fiercely oppose this expense, but when by such means as these tips, land, *practically valueless*, is made worth 5d. to 7½d. per yard, or a rental of from £100 to £150 per acre, I contend that the owner should be *forced* to spend some of this gain (towards which he had done absolutely nothing) on the land itself for the protection of the public.

Generally, you may assume that the additional outlay required for improving the dwellings of the poorer classes must be taken out of the value of the land itself, and this is one of the great difficulties in dealing with the question. If the landowner *will* have his price for the land, the builder *must* reduce the cost of the structure. As a rule, the public will not, or cannot, pay the additional rental required for superior work, and the necessities of the poor compel them to occupy buildings irrespective of their character.

We will now pass on to the brickwork in foundations, and I would here again impress upon you the necessity for seeing that the work is commenced properly.

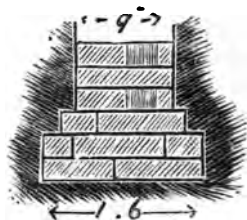
Now, what is the usual course adopted? The trench is roughly levelled, and the bricklayer puts in his first course dry, with rough pieces, bats and any kind of mis-shapen bricks. He then throws in a few trowels' full of mortar on them, and smooths the mortar over the top of this rude brickwork, and the foundations for his wall are then ready. Even in the next course he spreads some mortar on to receive the bricks, and generally lays a whole range of bricks on it, not making any attempt to fill the vertical joints; then throws a lot more mortar on the top and spreads it over. Sometimes you will see a man make some attempt to force the mortar down a few of the vertical joints with the edge of the trowel, especially if he sees you watching him. Of course, after he has smoothed it over, the work appears solid, but take a brick up, and you will find that perhaps the under mortar has squeezed up half an inch into the joint and the upper mortar passed downwards to the same extent; otherwise the joint is perfectly open. Now, in all cases I ask for the first or bottom course to be laid as carefully as the remainder; *more so*, if possible. Having first levelled the trench, place a good layer of mortar on *the ground itself*, and lay the first course of good hard bricks, full size, *not*

*bats*, which *should only be used for closers*. The bricks should be pushed along the bed into their place, so as to press the mortar completely into the joint, which will then be full to the top. The



Defective vertical joints in brickwork.

reason for using mortar at this first course is that I wish to attach the wall to the ground itself, not merely to support the wall on a number of points. The mortar takes hold of and adheres to the ground below, and secures the first course of bricks to it.



Footings to walls.

The footings, which should always be provided to every wall however small, are very often dispensed with. They should not be less than double the width of the wall itself—that is, a nine-inch wall should commence two bricks wide, and a fourteen-inch or one-and-a-half-brick wall, should commence three bricks wide, and the first two courses should be of the same width—that is, the bottom footing should be six inches or two courses thick, then narrowing by one-quarter of a brick each course until the nett thickness of the wall is reached. The object of these footings is, as the name implies, *to give the wall something to stand on*. We can readily imagine that if a man's legs terminated at the ankle he would not be, as the saying is, "very firm on his feet," but man (and the same thing applies to animals) has been formed with

proper footings or feet, so that he may stand steadily, and when we spread out a wall at bottom or foundation we are but following out the course which has previously been taught us by the Great Architect of the Universe.

I would also mention here that in all cases the basement walls of a building above the footings should be built hollow, or with a cavity, so as to ensure being dry inside, and provision should be made for admitting air to and from the cavity; in addition, a good damp course should be laid about the level of the basement floor, extending over the entire surface of the wall, so as to prevent any damp from rising, which it will certainly do if not prevented by some material which is impervious to water. Bricks are naturally porous, and the heat of the house will draw the damp upwards. The damp course may be of asphalte, *strong cloth pitched both sides, felt, or lead*. Slate is sometimes used, but I do not like it, as it is sure to crack and break with the pressure. It is also a good thing to coat the outside of the wall with pitch, or a mixture of pitch and tar—pitch about 3lbs., tar one gallon, a very little naphtha; generally mixed by guess. This will ultimately decay and come off, but in the meantime the wall has become dry and the mortar hard. As a rule, you will find the basement stories of small houses damp, and this damp in many cases extends up into the ground floor storey, disfiguring the walls and causing decay in the timber work. When you can do so, it is advisable to fill in the space next to the outside of the wall for about eighteen inches to two feet wide with brick rubbish, which will allow any damp getting at this part to pass at once downwards to a drain which is placed at the bottom of the trench. I have done this where walls have been damp. The top should be covered with cement, so as to prevent the water running off the walls into the space or trench, and to throw it outwards away from the wall, and a gutter may be formed in this concrete to take the water away.

I think we may now say something of the bricks themselves, and on this I do not know that I can do better than give you the opinion of the Manchester Society of Architects on the subject, as expressed in a pamphlet published by that society in 1868. A very large number of experiments were made on many different kinds of bricks, taken indiscriminately from buildings then in progress, and from brickyards. The dimensions, weights, and that which is of the greatest importance, the *porosity*, was tested in many hundreds of experiments.

This important pamphlet was issued during the time my friend Mr. James Murgatroyd was the honorary secretary of the society, and I think I am justified in saying that to him is due the credit of the paper.

Generally, the bricks should be well formed and straight, well burned, so that they may be able to stand the knocking about before and the pressure to which they will be subjected after they are built into the structure, and also that they may stand the action of damp, which is terribly destructive to bricks if they are not properly burned. They should also be sufficiently close in the material and non-absorbent, so as to take in the least possible quantity of water, and to be the longest possible time in doing it. The sizes of the bricks should be as nearly as practicable 9-in.  $\times$  4 $\frac{3}{8}$ -in.  $\times$  2 $\frac{3}{4}$ -in. thick, so that they will bond properly into one another, this being found a convenient size. The weight should not be much more than from 7 to 7 $\frac{1}{2}$ lbs., as we should consider the bricksetter who has to handle them, and the labourer who has to carry them. If you notice bricks, you will find that sound, well-burned bricks when struck together, have a clear metallic ring, which soft ill-burned bricks have not. They also break clear and without falling, as it were, to pieces.

I remember that some of the bricks experimented on in 1868 were so porous that when placed with the edge in water it fairly hissed as it passed into the brick, and one lot of bricks absorbed at the rate of 103 $\frac{1}{4}$ oz. to the cubic foot in a quarter of an hour, and 241oz. in two and a half hours, the full saturation being 254oz. nearly. One of the machine-made bricks submitted by the Manchester Society of Builders, weighing 8.92lbs. and 9 $\frac{1}{2}$ -in.  $\times$  4 $\frac{3}{4}$ -3 $\frac{1}{4}$ -in. in dimensions, absorbed 1lb. 5oz. of water, or 36.28 cubic inches, or 24.74 per cent of its bulk.

Another specimen, hand-made, absorbed (also to the cubic foot) 38 $\frac{3}{4}$ oz. only in a quarter of an hour, and 58oz. in two and a half hours, the full saturation being 127 $\frac{1}{2}$ oz. only. This is a great difference, and you may now imagine the state of a building built of the first named bricks after a steady driving rain lasting, say, three or four hours. It was also found by experiment that at a temperature of 65° it took about eleven days for the water to dry out of the bricks.

The bricks experimented upon weighed from 6lb. 9oz. each, or 109 $\frac{3}{4}$ lbs. per cubic foot, to 8lbs. 15 $\frac{1}{2}$ oz. each; and in some instances the machine-made bricks, although smaller, weighed 123 $\frac{1}{2}$ lbs. to the cubic foot.

I will just give you the summary of the opinion formed on this subject by the Society :—

“Bricks of good quality should be of uniform size, say 9-in.  $\times$  4 $\frac{3}{8}$ -in.  $\times$  2 $\frac{1}{8}$ -in., and should weigh at the rate of about 110lbs. to the cubic foot, or about 7lbs. each. They should be rectangular, with true faces, and only the sides and ends need be smooth. The arrises should be sharp and straight.

“No print sinking on either face.

“They should not absorb when saturated above twenty per cent of their bulk of water, and should absorb it reluctantly, and part with it with facility at ordinary temperatures.

“They should be uniformly burned and have a metallic clang when struck together. They should be tough and pasty in texture and not granular, so as to require repeated blows to break them, rather than one simple hard blow. Superiority in this respect will cause the bricks to retain their entirety, and sharpness of their arrises in carting and handling.”

The mortar used is also of importance. It is composed, as you are aware, of lime and sand, generally in the proportion of one and two. There are many kinds of lime used, and I do not purpose going into their consideration, beyond mentioning that the quick setting limes are generally the best. I myself never use what is known as Buxton lime for outside brickwork, or where such would be exposed to damp. I use the different Yorkshire limes, Ardwick for certain purposes, or lias with a very little Buxton mixed with it. The Buxton lime by itself does not set well in a damp situation. The sand should be clean and sharp, and free from clay or mud, the presence of which prevents the mortar from setting properly, and is liable to be washed out or softened by the rain. When sand is not obtainable, cinders make excellent mortar, but they should be cinders, and not ashes, and should be ground in a mill along with the lime.

The filling in of the joints of the brickwork, which I referred to in my remarks on the footings of walls, applies with equal importance to the superstructure, as not only will water make its way through from the outside more quickly and certainly, but smoke and dirt will find its way from the flues.

I will particularly direct your attention to the subject of *flues*. Now, a flue should be a perfectly formed tube, moderately smooth inside, so as not to afford any obstruction to the passage of smoke, which it is advisable to get away as quickly as possible; a circular

form is, of course, the best. Boys are not now sent up flues for sweeping purposes, therefore there is no object in retaining the oblong form, but as the circular form is not readily constructed in brickwork, a square flue seems to be practically the best form, as it is more readily and efficiently swept with the *circular brush*.

The Metropolitan Building Act provides that all flues shall be parged, or pargetted inside—that is, plastered. This I, however, very strongly object to. It is in my opinion but encouraging bad work, as the bricksetter is certain to take less care in building the flues and filling the joints if he thinks it is to be plastered over. This is but natural. The plastering, unless it is done in the best manner and with the best materials, decays and falls off in patches down the chimney to the great disgust of the occupants, and the soot also lodges in these places. Then the smoke finds its way through the open joints of the brickwork into the house, more particularly between the joists.

All flues should be built with good straight bricks, as carefully as any other part of the building which is intended to be seen, and the joints filled in solid and then struck with a small trowel, as if for whitewashing, and great care should be taken to tie the mid-feathers into both the back and front walls every few courses; this last is often neglected.

The grouting of the walls I also always object to, as, if recognised, it generally means building the back and front faces four or five courses high, half-brick thick, with good bricks, and filling in the inside with bats and rubbish, then pouring in from a bucket a thin mixture of mortar and water of the consistency of thick soup, which, even if it is fortunate enough to find its way into all the joints, but fills them with a very imperfect character of material. This you can readily understand, as the grouting must be thin, or it will not reach the joints, and when the water evaporates, or forces its way through a joint and escapes, what remains will be at the *best* but a sort of honeycomb without strength or capability of turning damp.

Brickwork should be built course by course, of good whole bricks, any closers being cut the full size required, and all the parts flushed full with *mortar*. No grouting should be required, nor any attempts to force the mortar into the joints with the edge of the trowel, which will not succeed. The nearer you can get to this class of work the better.

Before leaving brickwork I will mention two other things—one

is, that very great care should be taken with work where two kinds of materials are used, as, for instance, common brick walls faced with stock bricks, the stock bricks being set very close, and with carefully-prepared mortar or putty, and the backing of rougher bricks set with joints about  $\frac{3}{8}$ -in. thick of common mortar. Now, generally, in the cheaper class of property, a large proportion of the stock brick headers are cracked off, so that this makes practically two walls. Very often the inner backing compresses or sinks more than the out facing and the stock brick bulges out, either separating itself from the inner work or carrying with it the inner work.

The same applies to the backing behind stonework, which should be carefully built of good bricks and laid in quick setting mortar or cement. I have often noticed the backing to piers (when it has been half-brick and one-brick thick) quite loose, and in a few

cases have taken it down and replaced it with brickwork in cement. But, when practicable, in small piers the stonework should pass through the wall; there is really no excuse for backings of one-brick thick only; the cost of the extra stonework would be very trifling. You will see the importance of this matter if you will look at a pier built of stone, say ten feet high of ten stones, and say with ten joints, counting the bottom one. Now we know that masons, as a rule, are careful in making the beds of their stones level and straight, and in setting the work with close joints; in fact we may assume that the stone, by its own weight, will come down close, immediately, but certainly before the brick-layer commences to back up. Now, take the joints in the ten feet of brickwork and you will have about forty joints, averaging nearly  $\frac{3}{8}$ -in. each, or about 15-in. of mortar, which remains soft for some time and liable to be compressed if any weight is placed upon it.

You can therefore readily see how important it is if you are to have sound work, that the back part of the wall should be of such materials as will ensure its being as solid as the front part.



Brick backing to  
stonework.

In masons' work there will be less to explain than in brickwork. Generally the same conditions apply to the bedding of stonework, so far as the joints being fully and completely filled with mortar. This, you will readily imagine, must be of importance when you have true and neatly dressed joints or surfaces to deal with, such as is generally the case in stonework, especially where through stones occur. It is necessary that stone walls should be built with a cavity, if they are expected to be dry, particularly if at all exposed to driving rains, otherwise the water will pass through them. The great thing to be attended to in stonework is to see that the facing stones are thoroughly tied into the backing, whatever it is—brickwork or rubble. Proper through stones should be provided, and plenty of them, and the remainder of the facing stones should be not less than six inches on the bed. I have seen them used varying from six inches to three inches in bed, but this should not be allowed.

In rubble work, the stones should be of fair size, and should be laid so as to *bond* and work into one another, the object being to keep the wall together—to hook, as it were, one stone into another, so as to prevent the wall from separating. The small angle spaces should be filled with pieces of stone as large as can be placed there, and care taken that each piece of stone shall be solid, and shall not *rock*. You want the wall to be of stone, *not* mortar; but you should have the mortar put in first, and the stone pressed in afterwards. By this you will ensure solid work.

Again, great care should be taken that the stone, most of which used for building purposes is stratified or laminated like the leaves of a book, shall be placed on what is called its *natural bed*—that is, with the strata or leaves horizontal, in the same way that it was formed in the quarry. If this is not done, the action of the air in most cases will cause the laminae or strata to separate and fall away. This you will see in numberless instances in buildings where certain stones have been, as it were, eaten away for some inches in depth. There is no means of stopping it wherever it commences that I am aware of, though many attempts have been made, and ultimately the stones will have to be cut out and replaced. Stones should be marked on the top side at the quarry, so that the same position may be retained in the work. I would particularly direct your attention to defects in stone, and this is of very great importance to workmen.

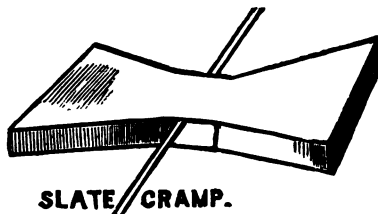
Before the workman commences, he should examine the stone

itself, and see if there are any defects in it which will show after it is worked ; if there are, he should call the attention of the foreman to the defects, and, as he proceeds with his work, should other defects be exposed, he should at once stop and call attention to them. Otherwise, when possibly he has expended some pounds' worth of labour on the stone, it may be condemned. I have often noticed this, and have had to condemn stones when a little thought on the part of the workman would have saved his employer some pounds : the stone, as a rule, is not wasted ; if it will not do for this particular purpose, it will cut up for something else ; but possibly after it is worked it may be useless ; a little thought would tell you that it would not be allowed to be used, and if overlooked at the time would, if found out, have to be cut out of the building and replaced at considerable expense. I remember once having to discard one of two large gate-posts, something like three feet square and seven or eight feet long. As soon as they were delivered they were propped up from the ground ready for working, although a heavy frost after rain had just set in. Directly I saw them, I ordered them to be dropped on to the ground and covered, but I was too late with one, which was ultimately found to be cracked, but attention was not drawn to this by the workman until the stone was nearly completed, although he knew it. The consequence was a delay of some weeks' time in completing the work, and a loss of many pounds in money to the contractor.

The beds of stonework which rest on brickwork should be attended to better than is usually the case. Very often the idea seems to prevail that the quarry scappling is sufficiently good for this purpose, and the stone is fixed and packed up with bits of slate, or stone or brick, as may be required, to bring it to its proper position. This is a great mistake, as upon this bed the entire weight of the superstructure rests. The fact of its not being exposed to view should not be considered at all.

Cramps and dowels are a very important part of a mason's work, and it should be remembered that metal which has any tendency to corrode should not be used in these, or if used should be carefully protected. Copper or zinc may be used, or thick slate cramps if there is sufficient substance in the stones to admit of their being formed of proper size, and they should be sufficiently long to avoid the usual bursting off of the portion of the stone gripped by the cramp. Dowels are the same ;

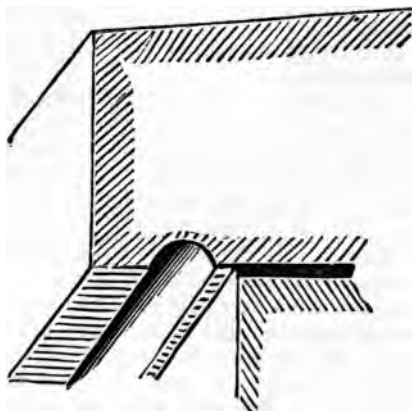
they should either be of copper or of slate, but never of iron. The peculiarity of iron is that in rusting, when enclosed in a stone it is not eaten away, and does not get smaller, but throws out a skin or oxide with irresistible force. You may therefore, almost in any



**SLATE CRAMP.**

old building where iron dowels have been used, see pinnacles and shafts split, and if you get at the dowels you will find them swelled beyond the original size.

Care should be taken with throatings to sills and all other projecting portions of stonework. In many cases these are made in the most slovenly and insufficient manner, being little more than a scratch or line. They should be clearly cut and of fair depth, never less than from  $\frac{1}{4}$ -in. to  $\frac{3}{8}$ -in.

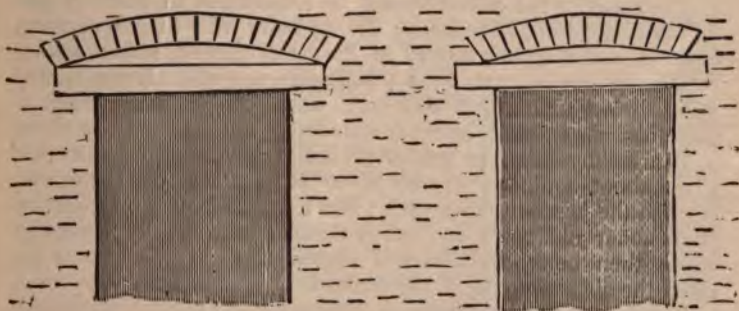


**Throating to stonework.**

Coming back again to the subject of the lower part of the building, I would suggest to you the advisability of using in ordinary

structures as little timber work as is possible in the basement. I of course do not in this refer to basements of expensive properties or business premises, but in ordinary cellars. How often do you find ordinary basements looked after properly, and in how many do you find damp and decay? Wood lintels should not be used in basements, nor door frames if you can possibly avoid it. The lintels may be dispensed with altogether without any difficulty, and in the majority of cases the doors are not required excepting for, perhaps, a larder and wine cellar, and for these we can use codge or hanging stones, and hang the door with bands and gudgeons.

One thing in particular I would mention in connection with lintels, if of wood. In all cases they should have relieving arches over them, and these relieving arches should spring from the end of the lintel, not over the opening only. If this is attended to, the decaying of the lintel will do no harm.



Relieving arches over wood lintels.

Bond timber should never be used in walls, and is only now put in the cheapest buildings. Hoop iron is much better, and if well tarred and the ends turned up round a brick, answers the purpose much better, and is really of use. I as much as possible keep the basement windows above the ground, and fill in the openings with cast-iron gratings, providing a loose sash inside to be lifted into its place and secured with large turn buttons. These are only required during the winter months; all the rest of the year the gratings are sufficient, and the basement will then be sweet and cool. By this course you will get rid of those filthy nuisances,

cellar window areas, which, in the majority of cases, are filled up a considerable distance with rubbish and leaves, or other refuse, retaining moisture and rotting the lower part of the window frame.

It is generally advisable to make an area to an opening in one of the cellars, for the purpose of placing in it a trapped grid, towards which all the floors of the basement should fall, so that they may be washed or swilled out. This area should be a few inches below the level of the floor at its lowest part, and the opening to it should be closed with a door opening inwards, the upper part being of glass to serve as a window. The area should be of fair size, say two feet wide at the least, and may be protected at the top in any way which will meet the circumstances of the place. Now, this area will have to be kept clean if the cellars are used; if it were not, the grid would get stopped up, and the water from the cellars could not get away, so that attention would be soon drawn to it.

The floors of the cellars should be impervious to wet. A few inches of good concrete formed of lias lime, with brick and stone cuttings, and a surface formed of Portland cement, with a screed or skirting extending about two inches up the walls all round, will make a good and lasting floor. All should, of course, incline or slope towards the area before-mentioned outside the window door.

The ceilings also in cellars should be plastered between the joists about half way up, so as to prevent any draft upwards through the joints in the boards; but I should prefer pugging the floors about 3-in. thick on boards secured between the joists, the whole then being whitewashed underneath. If this course be taken the air can get to all the timbers.

As to the timbers themselves, all (the bearers especially) should be clean sawn; never allow any part of the round to be left on. Generally, that part is not sound and soon decays. Also, be careful about shakes and knots in beams. You are no doubt aware that the lower part of a beam, when fixed, is in a state of tension—that is, if you draw a knife or saw across it, it will open out, but if you do the same on the top side of the beam you will find that it will close up and fasten your knife or saw, as that part is in a state of compression. A certain line along the beam is called the neutral axis, along which there is no strain. I am not going into the question of the strengths of materials with you, but I mention this because I wish to call your attention to a matter which should be known to all workmen, but which, I am sorry to say, is not

always attended to. Very often you will find in a beam or joist a good sized knot, extending right through the piece; of course, if that is a dead knot the piece should not be used; but assuming it not to be so, do not place it at the bottom, where it will be subjected to a tensile strain, but turn the piece up, so that it will be in compression, and it will then do no harm. Remember that if there is any defect in the tensile side of the joists, the strength of the piece is reduced by the size of that defect; for instance, if in a joist eleven inches deep, a saw kerf be cut two inches deep, the joist is reduced practically to nine inches deep all over, and you have wasted two inches of your material the whole length of your joist; the same applies to the top part if a piece is cut out, but the joist is not weakened to any extent if the groove on the top, after being cut out, is plugged or wedged tight up again. This now reminds me of the sins of plumbers and gasfitters, who will, without the slightest compunctions of conscience, cut a groove two or three inches deep right across the middle of a range of joists to carry a gas pipe to a chandelier, thus at one cut reducing the strength of the floor from 11-in. joists to 9-in.

Some years since I altered a house on the Cliff, Higher Broughton, and found that the floor of the principal chamber inclined towards the centre of the room very perceptibly, perhaps nearly two inches. On removing some of the boards to examine into this, I found a good double-framed floor formed of beams with ceiling joists below, and about 5-in.  $\times$  3-in. oak joists above to carry the boards. But some ventilating genius had cut a channel right across the middle of the joists in the centre bay, and put in a 4-in.  $\times$  3-in. zinc tube for ventilating the room below above the gas chandelier. This tube then passed through the wall into the open air. There was but about  $1\frac{1}{2}$ -in. of the joist remaining to support the boards, and of course they had given way. Always bear in mind that, theoretically, a beam, so far as strains are concerned, assumes this form—



so that, if you want to cut out a piece or a groove for pipes, cut it close to the bearings on walls, where it will do no harm, and then

pass them along the side of the joist to their places. A few feet of lead piping is of very little value.

As an instance of the importance of examining timber before it is used and of judgment in using it, I will refer to a house built under our own supervision many years since. Some three or four years after it was finished, one of the hearth trimmers gave way above the drawing-room, cracking the ceiling and doing other mischief. On examination it was found that there was a dead knot close under the mortice in which the cross trimmer rested, and this part had given way. That piece of timber should not have been used in this place, or, if used, should have been turned upside down; the probability is that no accident could then have happened. The value of the piece of timber which would have been wasted by cutting this end off would be a few pence, but it cost some pounds to make good the mischief when found out.

Now, with regard to beams, do not build them into the walls, but place them on stone pads, or, better still, in cast iron boxes, and leave a space all round so that the air can get to them. Ends of beams which are built in walls very often decay, especially if there is the least damp which can get at them.

During the last ten or fifteen years dry rot seems to have been more prevalent than before, at least we seem to have heard more of it. It is one of those things which has not yet, to my mind, been satisfactorily explained. It makes its appearance without notice in all kinds of places, and where you would least expect it. It gave me trouble some years since in an old house, making its appearance in a beam over an open cellar, right in front of a grated window, and between that and a grated door. There was a clear draught through the cellar. I ultimately took down the beam and substituted a rolled iron joist. In another instance it attacked the floor of part of a mill in which there were ventilating gratings about 14-in.  $\times$  6-in. in the walls on each side. In this the fungoid growth was the strongest close to the ventilating openings, and in several instances the fungus had travelled about eighteen inches through the wall in these openings towards the street.

In 1864 we removed the basement floors of a range of warehouses in New Brown Street. The 3-in. plank had been destroyed by dry rot. It was found out by the tenant putting his foot through the planking in stepping off the stairs, and I think I never saw a more beautiful sight when the boards were removed. The entire surface of the ground was covered with the fungus in

great masses, a white and brown livery substance, which must have been nearly two feet thick, no doubt the growth of some years. Now, in these warehouses, care had been taken by the architect to provide air-channels from the window areas at each side of the building to underneath the floor, but these had not saved the floor; perhaps there was nothing to induce a movement in the air. In replacing the floors, we made connections between the underside of the floor and the flues, so as, if possible, to create a draught, and having removed all the timber work, washed the place well with vitriolic acid and covered the ground with concrete and asphalte, so as to keep down any damp; also tarred the underside of the planks. We have seen no signs of decay since then, and I have just completed some alterations in one of the warehouses recently. But the curious part of this matter is that in 1864 we examined the floor of the adjoining warehouse and found it quite sound, but we could not find any ventilation whatever to the underside. We, therefore, closed it up again. In 1879 this last warehouse again passed through my hands, and I examined more carefully; but there is no ventilation at all to the underside of the floor. I mention this because it is said that dry rot is brought about by want of ventilation.

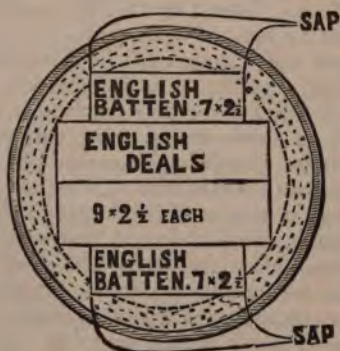
Some years since the Council of the Manchester Society of Architects tried to get together some information bearing on this important subject. I (as secretary) received a few communications, but very few. I think it is a thing that architects do not like to say much about. So far as I can find out, it is a vegetable growth, and I have heard it said that the seeds are brought over in almost every cargo of timber which comes to England, but that it requires a particular combination of heat and damp, and perhaps something else, before the seeds will germinate. If this is so, it would account for its non-appearance for many years and its sudden appearance without any visible reason. I have never, however, been able to satisfy myself as to its cause; the want of ventilation, to my mind, does not of necessity induce its growth. Some time since I was consulted by an architect who had been called in to examine a chapel where the dry rot had attacked the roof and was then travelling downwards, having at that time reached the gallery.

The best course I can suggest is what I have previously stated. As much as possible do without timber in the basement, which is the most likely to be attacked, and provide as much ventilation

and light as possible, and cover the ground with asphalt or concrete, if underneath a floor, so as to keep out the damp, and also avoid using spruce or Swedish timber for these parts; use sound red deal, or oak if you can afford it. I know that you will have difficulty in respect of ventilation, because as soon as the tenant finds an opening through which air can come he will close it up. You can, however, provide it.

In selecting the timber I would now refer to the use of such as has sap in it. This is a most important matter, whether the material be for framing or joiners' work. Of course, if this part of the timber be cut off there will be a certain amount of loss or waste, but it is really trifling comparatively, and I am sure that any person would willingly pay for that amount so lost sooner than have it placed in a building, if he only understood the meaning of the term and the result also.

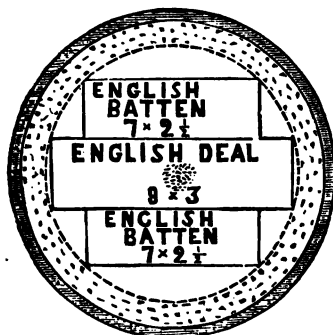
Sap is valueless altogether; practically there is no strength in it, and as it rapidly decays, it even influences the remainder of the otherwise sound material. On no account should it be used in any



English battens with sap at corners.

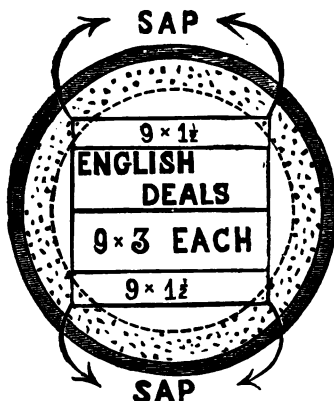
part of the building, but I am sorry to say that a very great deal more does get into buildings than should be the case. This is the more to be regretted, as the value of the material thus palmed off on the owner improperly is so trifling that it cannot be an object to any respectable contractor, and if a few pieces of scantling or framing be discovered and have to be removed, the cost of

such removal will far exceed any possible gain which might have accrued to the contractor by its use.



Deal with heart left in, liable to decay.

We will therefore assume that when such is sent to a building it is by mistake, in which case it behoves the workmen (who



French deals with sap at corners. Copied from Britton on Dry Rot.

should take some interest in their work), and the supervisor also, to see that it is put to one side for use in other ways.

Generally, I would suggest to you on no account to box in or close up any space which can by any means be left open. All

spaces in roofs should be easy of access, and should have glass slates over them, so as to give light and avoid the necessity of taking candles or matches into them.

Cupboards should not extend to the floors as a rule, but the bottom shelf should be raised six or eight inches at least from the floor, or perhaps placed at the top of the skirting, so that the floor can be cleaned underneath. These spaces are always useful, but remember that your best endeavours should be to make every part of the building easy of access and easy to be cleaned; places which are out of sight or not easy of access are very often neglected.

Iron is a material which is very deservedly taking a foremost place in all building operations, and of late years it has been rolled into so many convenient and usable forms that in most cases you have but to look over the lists and you will find exactly what you want. It is also so cheap, comparatively, that it may be used to a considerable extent in the ordinary class of houses. Lintels should be formed of it, especially in outside walls, and all floors which are intended to be tiled, such as kitchens, pantries, passages, &c., may also be formed with rolled joists; very light sections of iron may be used spaced about 12-in apart, and these spaces filled in with Portland cement concrete, which will give you a good solid floor upon which tiles may be laid with safety and also satisfaction. The old-fashioned way of deep joists with pugging boards and strips between, and six or eight inches of concrete or sand filling and covered with flags or tiles is very heavy, the timbers are liable to decay, and the floor is hardly ever solid. There is an economy of space in using the iron for floors also, as the depth of iron joists required is so small compared with the timber joists and beams. What we want now is some system of laying wood tiles in a kind of glue or cement which will adhere properly to both the wood and the concrete, so that we may have a warm and reasonably cheap floor suitable for living rooms. This is now done by Nightingale and Co., of Great Grimsby, but I have not tried it yet, so cannot pass any opinion on it. Bearers and boarding takes up room in height, and also retains the objectionable hollow space under the boards which should, if possible, be got rid of. The principal thing I would impress upon your minds is that the weakest part of a piece of iron is its greatest strength. What I mean is, that in all cases, if you want to get at the greatest strength of a piece of iron, you must measure it at its weakest part, as it will give way there first.

If you are putting in a tie bar, say 3-in.  $\times$  1-in., and you drill or punch a hole through it 1-in. diameter at any part, you are wasting the material, as at that hole you have reduced the bar equal to 2-in.  $\times$  1-in., and assuming the iron to break with a strain of twenty tons to the square inch, then, instead of the tie bar breaking with its full strain of  $3 \times 1 \times 20$ , sixty tons, it would break at the rivet hole with forty tons. You therefore see the importance of what I name.

I some time since had an arch let down by this very thing, where heavy cast iron springer plates, with strong tie rod, had been provided, and fixed below ground, and to my consternation the arch began to give way. On enquiry, we found that by some accident the tie bar had been sent to the building in two lengths. The foreman, instead of getting it properly pieced up, had got a few holes drilled through it, and secured the two ends with some bolts. Of course, it gave way as soon as the weight came upon it, but fortunately was found out before very serious mischief had arisen. Still, it cost the contractor a considerable amount to rectify this blunder.



The same principle will govern in dealing with straps, such as are used for the king posts or feet of principals, and where gibs and cotters are used. A sufficient amount of metal should always be left at the end of the slot, in which the gibs and cotters are placed, to ensure its not being burst out, and the sides should be thickened out so as to compensate for the part cut out for the slot.

When bolts are used in timber work, always use large square washers under the heads, the screwing up of the nut then does not injure the timber. A little thought on this subject will show you the necessity for this, as you will notice the small amount of timber which the nut rests upon, or which an ordinary washer covers. Remember that the ordinary washers that you get with bolts are intended for use on ironwork, not on woodwork.

I have endeavoured in the limited time which is of necessity at our disposal to bring before you, as clearly and forcibly as I

could, a few of the matters relating to the subject of foundations and materials of construction which particularly require your attention. Many of them seem to be matters of small moment, and hardly worth mentioning; at the same time you will find them very important when you consider the possible and probable results of a neglect of them. All that I have told you I have seen, so that I am not talking either from hearsay or about matters which may occur. Now you must endeavour to learn from other people's dearly-bought experience; it is by far the cheapest and the most pleasant. Keep your eyes and ears open, and get all the information you can, even about what may at the time appear to be the most trifling things, always remembering that it is sure at some time or other to be of service to you.

Every one of the trades is worthy of a full night's consideration, and if what I have said this evening should lead your thoughts in the direction by which you may obtain further information, I shall not regret the time which has been expended.

# PLUMBING.

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By W. R. MAGUIRE, ESQ., F.R.M.S., SANITARY ENGINEER.

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**P**LUMBING, or the art of casting and working in lead, claims a great antiquity. Lead undoubtedly was worked contemporaneously with silver, and is mentioned in the oldest known writing, the Book of Job, as existing four thousand years ago, in patriarchal times.

We know that Italian plumbers wrought so nobly two thousand years ago that their leadwork remains unto this day in the excavations of Rome, Pompeii, Bath, and York as worthy monuments of the ancient dignity of the art. We know that five hundred years ago English plumbing had been well established, for we find in 1365 an ordinance of King Edward III., followed by others of Henry VII., Henry VIII., and Elizabeth conferring privileges and legislating for the protection of the mutual interests of the public and of the craft. While those who follow the art of plumbing may indulge in legitimate pride over the antiquity of their calling, they must not endeavour to maintain their precedence "on the claims of long descent" alone, nor forget that in an honourable handicraft, as in blue blood, "'tis only noble to be good," and that high rank and ancient lineage always imposes high obligations.

The public, I fear, does not look upon plumbers as a class with admiring, nor even with friendly, gaze. Plumbers are only sent for in moments of dire necessity, and when they come are treated as if they had produced the evil that they are called on to set right. This aversion and ingratitude is perhaps not altogether unreasonable, for, owing to the nature of the work they are engaged on, plumbers are obliged to make their unwelcome presence disagreeably felt to the ears, eyes, and noses of the residents—lighting blazing fires in the hottest summer weather and extinguishing fires in the depths of frosty winter, tearing up and down the stairs with heavy boots (their work generally being at the greatest distance from the fire where they heat their irons), and playing Tom and Harry generally with the household. Unfortu-

nately, plumbers are condemned on every pretence for having done what they ought not to have done, and for not having done what they ought to have done.

But it is not only outsiders who call us bad names; we positively seem to rejoice in blackguarding ourselves. I never heard such hard things said of plumbers as I listened to at the recent banquet of the Worshipful Company of Plumbers in London. The speakers not only abused themselves and their craft, and recommended reform on all sides, but they were applauded by the Worshipful Company to the echo. They recalled to my mind Daniel O'Connell's famous address to a crowded assembly of his admirers in Tipperary, which he concluded in these terms—"Me brave counthrymin, aren't we all discinded from the ould Irish Kings?" and his audience cheered and shouted in hearty response, "We are, we are, we are!" "Aren't we all the thrue Milesian sons?" "We are, we are, we are!" "They call us a nation of blackguards, are we that?" "We are, we are, we are!"

Modern plumbing has been severely dealt with no doubt, sometimes on insufficient evidence, sometimes on false issues and by incompetent judges, but as the public constitute the *final* court of appeal, plumbers *must* accept *them* as their judges, and labour for a more favourable verdict in future.

If ancient plumbing attained great importance and honour, how much more important and how much more honourable should be the position secured by modern sanitary plumbing? That it grows more and more important every day is a fact beyond our control, but responsibility rests upon the individual members of the craft to maintain a corresponding growth in its honour and dignity, so that, having its roots struck deep in the experience of an ancient and honourable past, it may blossom in the increasing knowledge and labour of the present, and that its fruit may be for the healing of the nations.

We see the City and Guilds of London, the Sanitary Institutes, the Sanitary Associations (such as this which I am now addressing) working with energy and perseverance throughout the kingdom, and fighting the battle of Public Health. Now the Plumbers' Guild is joining in the fray; the clash of arms resounds throughout the camp, swords are sharpening, armour riveting; we have drilling in technical schools, studying for test examinations, attending lectures, and practising handiwork, so that before long Modern Plumbing may take the front rank of the crafts labouring for the

benefit of mankind. Such, at all events, is the hope of all earnest sanitary workers.

In treating the subject of Plumbing within the limits of a short lecture such as this must necessarily be, I experience the difficulty of selecting what details to omit. Twenty such lectures would leave fresh subjects for twenty more.

I shall confine my attention to Sanitary and Insanitary House Plumbing, as of paramount importance to public health, giving you such hints as may occur to my mind from the retrospect of one thousand five hundred sanitary inspections of dwellings, and from an active practical experience now extending over a quarter of a century.

Sanitary and insanitary plumbing—the good and the bad—are not even yet clearly distinguished by the public; they grow still together, like the wheat and the tares, but it is full time to separate them; and to do so with certainty we should be well able to detect the marks of difference.

When dealing with domestic plumbing, we should remember that the private house drain and the cesspool, or public sewer, with which it communicates, may have been so improperly designed or constructed that foul air of a dangerous or offensive character may arise in, and be drawn from, them. We know as a fact that such dangerous air arises in them, is drawn into houses, and there causes illness and death; yet we act, or refrain from acting, as if we were ignorant of the greatness of the danger.

It is now admitted that although sewer air becomes harmless when freely mingled with fresh air, it rapidly becomes a dangerous concentrated gas when confined in unventilated pipes or drains, so that one bubble entering a dwelling may, and often does, convey with it the germs of disease. Sanitary plumbing *prevents*, while *insanitary* plumbing increases, this danger.

Dr. Pridgin Teale, of Leeds, is far inside the mark when he attributes only one-third of the incidental illness of the kingdom directly to defects of plumbing and drainage.

Out of more than one thousand dwelling-houses which I have been called on to examine, from noblemen's mansions to small cottages, I have found only fifty tolerably secure though faulty, and only twenty free from defects of plumbing and drainage.

Elsewhere I have tabulated a list of fifty specific insanitary and dangerous arrangements commonly discovered in dwellings during sanitary inspections.

I shall assume that an abundant constant supply of wholesome water is available at a pressure sufficient to deliver freely at the highest level of the house. We will not permit deliberate waste, but we shall not be satisfied with any less favourable conditions at starting than a constant supply. The Waterworks Authority will probably, at your request, convey the water in a half-inch pipe from their mains to the boundary of your premises, where they require you to bring your house pipes to meet theirs, with a proper stop valve attached.

At this point the plumbers' responsibility commences, and every step he takes in fitting the house plumbing he will do well (and his employer will do better) to remember that upon his forethought, skill, and honesty depend the comfort, the health, and at times even the life of the future residents. The strength of the supply pipe will be determined by the Waterworks Authority in accordance with the water pressure, but as the power of frost is supreme, the strongest pipes should be sunk two feet at least underground.

It is good practice to fix a second stop valve, within easy reach, on the pipe inside the house wall, that the house supply may be stopped in a moment in case of accident or hard frost, and if the scullery trough, as usual, be at hand, take two branch pipes, one from outside and one from inside this stop valve, each having a separate draw-off tap fixed closely side by side, so that they may be used together to expedite the filling of cans. The outside draw-off tap is intended to deliver water to the scullery when the stop valve at the house side is closed off, in case of hard frost, or repairs to the house pipes, and the inner draw-off tap is intended to empty the house pipes when the stop valve is closed. If no trough is at hand, these draw-off taps may be fixed over a surface grating and trap, safely disconnected from the drain, and discharging in the open air outside.

In passing, let me absolutely insist on the total disconnection from the drains, of all floor traps and gratings, and of scullery or pantry trough wastes and overflows; let no quarter be given or taken on that point.

All water pipes, once for all, must be effectually protected from frost by covering them or laying them in warm places, away from outer and along inner walls, and arranging for emptying them in very severe frosts.

*In ordinary plumbing work, you will frequently see pipes hung*

along the walls on hooks, and sooner or later these pipes drag down and form festoons from hook to hook. All horizontal pipes should be laid upon thorough timber supports, previously well secured to the walls, rising with a regular slope, no matter how slight, for the double purpose of facilitating the upward escape of air bubbles when water is passing through, and the downward flow of water when the draw-off tap is opened to empty the pipes in severe frost. In ordinary dwellings, where the demand for water is not very great, and the supply constant, all water may be, and under some waterworks regulations *must* be, taken direct off the rising main as it passes upward to the water-closet cisterns. The water will be delivered thus free from all risk of cistern or storage pollution, but the supply may sometimes be cut off in time of frost, or during repairs of street mains, which I have known to occupy four days.

Continuing the rising main through the house, as many stop valves as there are distinct sections should be fixed; for instance, if there be one section leading to a return building, another to the top of the house, another to the stables, a stop valve and a means of emptying each section without interfering with another will prove a great advantage. In dwellings in the suburbs, where much water is required, it will be best to convey the main supply pipe direct to a very carefully arranged store tank at the highest level, fixing a ball tap on the pipe in the tank, and taking no branches off the rising pipe except those for supplying water for drinking purposes.

The position of this store tank is of extreme importance. A small room should be especially reserved for a tank room, amply lighted and ventilated, yet secure from frost, fitted with an air-tight door, with lock and key, and used for no other purpose than the safe custody of the main store tank.

The floor, walls, and ceiling of this small chamber should be rendered impervious, to exclude doubtful air, and glazed or varnished, not to retain dust. The tank should be raised above the floor to give easy access underneath for cleaning or repair.

Slate is the cleanest and coolest material for such a tank, but cast iron may also be safely used. When water is quite free from mineral salts, and as pure and soft as the Dublin and Glasgow waters, it acts upon lead when in contact with it for some hours, and becomes dangerously impregnated, so as to cause symptoms of lead poisoning in those who drink the water; the slightest

admixture of mineral salts in the water prevents this injurious action on lead. I think that the danger has been exaggerated, but yet would advise caution in the use of lead-lined store tanks. A very slight proportion of tin alloyed with the lead also prevents any injurious action. The pipes and sheets used in the Dublin Waterworks are required by the authorities to be made from such alloy. Strong wood tanks lined with this alloy in sheets 7lbs. to the square foot form durable and safe storage tanks.

I have thoroughly tested the Bower Barff process on wrought iron boilers, and have found the iron to rust so rapidly in contact with the pure Dublin Vartry water that I consider the process useless under such circumstances. Zinc galvanising over iron also gives way, and is not to be recommended for the storage tanks of potable waters.

Store tanks require monthly cleansing, and must be emptied rapidly and easily, else this duty will be neglected. The condition of some water tanks is disgusting and dangerous enough to warrant the waterworks authorities in discouraging the use of them until the consumers are taught the importance of keeping them cleaned. But in many towns the authorities forbid the use of stand pipe overflows with ground in wastes and washers at the lowest level of the tanks whereby they might be cleansed easily. They allow only overflows taken from the top of the tanks to some point where they shall give warning, if any waste occurs, and so that the foot passengers below sometimes get the whole of the warning unexpectedly, and have then been known to make very hot remarks on the subject of waterworks authorities.

Care should be taken to discharge these overflow pipes in the open air, free from all danger of foul air from soil pipes or vent shafts entering by them to contaminate the water in the tank.

The size of the store tank should depend on the number of residents in the dwelling, and the chances of the main supply being occasionally cut off. In suburban and country mansions, even with a supposed constant supply, there is greater risk of water being cut off than in town houses, and tanks should be proportionately larger. In many town houses store tanks are not necessary, and unless they can be maintained scrupulously clean and uncontaminated they had better be avoided altogether. A lead downward distributing pipe is taken direct from the main tank to the basement, and all branch supply pipes to baths, troughs, boilers, water-closet cisterns are taken off this pipe.

It is a good plan, where the practice is not against the regulations, to affix a hose tap on the water pipe at the basement, and to provide a hose for cleaning windows, walls, and corners of basement and yards. Cleansing facilities are not appreciated as they should be. I believe that in Manchester, domestic water supply must not be so used—perhaps the temptation to wash out basements, yards, areas, and to cleanse walls, windows, and drains would prove too much for the water supply; but it can be arranged for by meter for such useful purposes. In Dublin we pay £1 for such arrangement per annum.

Each water-closet should be provided with, and supplied from, its own reserve cistern, these cisterns in turn being supplied from off the main through ball cocks. In my district, although the printed regulations demand waste-preventing cisterns for closets, most happily the demand is not enforced, and consequently the household and servants do not feel themselves under the usual obligation to waste all the water they possibly can, wherever it will waste, through baths, or basins, or troughs, to keep the drains clean.

Waterworks regulations limiting the supply of water for closets to two gallons are simply unfit for publication, as tending to induce foul practices. They should be classed for ever in the Index Expurgatorius as demoralizing literature, poisoning with bad air those who honestly follow such filthy teaching, and encouraging deceit and underhand practices in those who decline to submit to be thus poisoned. A well-directed and delivered flush of double two gallons as the regulation quantity of water to closets is *not* waste of water for domestic purposes, while probably at the reservoir the waters are wasting headlong by thousands of gallons daily over the bye wash, and hundreds of public stand pipes in the alleys and court-yards are dribbling hundreds of gallons an hour to utter and useless waste.

If free-born citizens intend to establish a right to breathe pure air they must secure more than a two-gallon flush for their water-closets. If so-called water-waste-preventing cisterns must be used they should contain at least three gallons of water; less is quite insufficient to flush-clean the basin, trap, soil-pipe, drain, and interceptor, and as four gallons would be more effectual, why should the amount be curtailed?

Waterworks authorities will find in their dictionaries that the meaning of waste is useless expenditure or loss; to waste water is

to squander it, to destroy it, to keep it unproductive, lying unused and stagnant, while public health demands it to flush soil pipes and drains of their foul contents.

We must only hope that our waterworks authorities may soon remember that in naming some of the great attractions of the healthiest country in the world, we are told it was "well watered everywhere," then perhaps they may repent and enact bye-laws to compel the citizens to use as much water as may be found requisite to thoroughly cleanse their fittings, instead of restricting the fair use of water as they do now. There are numerous varieties of these waste-preventer cisterns; patterns of those approved are shown at the waterworks offices. They are made double, with two valves, one always open, one always closed, giving only a certain flush as required each time of use. Others discharge their contents by syphonage, started either by a small valve or by a plunger displacing some of the water.

Having distributed the cold water arrangements pretty freely, we must now decide on the best means of supplying hot water, as essential to health, in dwellings, and then we must hasten on to consider the plumbing work of other sanitary fittings.

Modern dwelling-houses will generally have high pressure boilers behind the kitchen range (unless they have independent boilers) for the hot water supply. The boiler, though not strictly plumbing, is certainly so near the lead piping that it is the next thing to it, and besides, it comes under the head of water pressure, and often gets the plumber into hot water, so I must interfere with the boiler a little.

These kitchen boilers, when judiciously treated, are decidedly warm-hearted, and well disposed to circulate their genial influence all over the house, but when they are badly used they sometimes kick up such a terrific row through the house that the inmates imagine nothing short of earthquakes in divers places, and when they can bear the noise no longer they send for the plumber.

If the boiler is making all this fuss, he will be suffering either from wind in his stomach or from a stoppage in his circulating tubes or his inside, tending to choke him to bursting. If the noise be a soft and regular one—thump, thump, thump—heard all over the house where the pipes run, you may safely diagnose air lodgment as the complaint. If the noise be a succession of sharp loud irregular raps, as of iron struck with a hard wood mallet, you will probably be correct in deciding that a deposit is

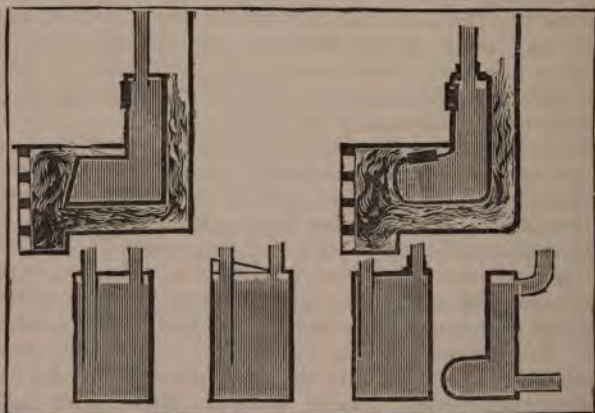
choking the flow or return pipe, or both, and you will apply prompt remedies to prevent fatal rupture. Every high pressure circulating boiler should be so made and fixed that no bubble of air can find an abiding place in the interior, or in other words, so that the boiler shall be always absolutely full of water in actual contact with the whole internal surface.

The ordinary boiler, in section like a boot, is very often improperly formed and badly fixed. Every boot boiler should have the top of the boot—the instep—sloping upwards from the front, or toe, to the back. When flat, some internal inequality of surface will be found to hold air, and thus create constant noise and be a cause of weakness where the boiler is exposed to fierce heat by keeping the water from internal contact with the iron or copper plate. The boiler toe next the fire should be rounded, not angular, and sharp angles should be avoided where in contact with fire or flue heat. Every such boiler should have a perfectly smooth level top, or be otherwise formed to secure the easy exit of every bubble of air through the outflow pipe.

Manholes should be provided both on the top of boot and on the front of the body of the boiler for efficient cleansing. In fixing the outflow, the end of the pipe should not be entered one hair's breadth below the inner top surface. A flange socket screwed down on the top of the boiler, into which the outflow pipe can be screwed, the hole drilled in the boiler being one-eighth of an inch smaller than the outer diameter of the pipe, will effectually prevent the pipe entering the boiler if screwed down too far in the socket. For the same reason, the outflow pipe should always be led from the top plate, as it is almost impossible to take it from the side or back without leaving space for air. I give diagrams of these methods to explain the dangers. For convenience of manipulation in fixing and cleansing, I prefer the return pipe carried through the top of the boiler also, and extended to within six inches of the bottom inside by a short piece of pipe of the same diameter as the return pipe screwed on. The outlet and inlet pipes should be kept as wide apart as possible, to leave space for the flue damper to work between them, and also to allow the boiler to be set slightly out of level, the outlet end being, say one-eighth of an inch higher than the inlet, to ensure free escape of air bubbles; if the outlet is not drilled at the extreme end of the boiler, then the top must be set dead level, else the bubbles will lodge at the extreme end beyond the outlet and cause trouble. (See diagram.)

Every boiler should have a pipe taken from its lowest point with a plug stopper or locked valve for cleansing, but no pipe for drawing water for house use should be taken off the boiler direct.

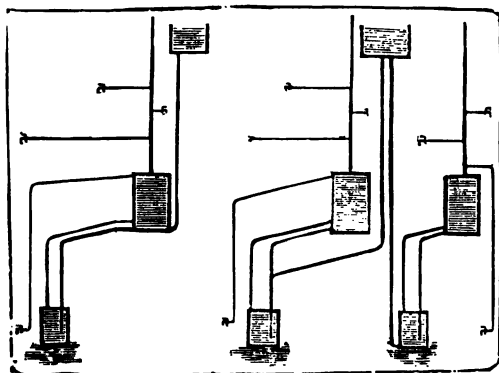
The intermediate hot cylinder system of circulating hot water pipes is now generally adopted; it is safe and certain to yield hot water when hot water is wanted. We know this is not the case with hot cisterns placed on the same level as the cold cistern, generally hidden away in a roof, where we have to creep on our hands and knees, as if we were exploring the recesses of the Pyramids of Egypt; have no light to see, nor room to turn when we get there, and now and again succeed in setting fire to the house in striking matches or letting sparks fall from our taper. The



intermediate cistern of galvanized iron or copper may be placed in such a position above the boiler level as to allow a quick gradient to the circulating pipes, within say ten to thirty feet from the boiler, and where heat radiated therefrom may be utilized as in a linen closet. The hot cistern should be tested to stand double the pressure due to the head of water from the cold cistern. The best form of cistern to resist pressure is a cylinder, though any form capable of resisting the pressure is admissible; a cleaning door screwed down securely should be provided for each hot cistern. Five strong screwed bosses should be affixed to the hot cistern and galvanized over after being fixed—two on the top and

three round the bottom—in proper position to receive the two circulating pipes, one supply pipe, one basement draw-off pipe, and one upward expansion pipe.

In general practice no question of importance arises concerning the arrangement of these pipes, except as to the cold supply pipe. Some authorities contend that it should be led direct into the boiler, but I hold it to be bad practice to allow dead cold water to enter a very hot boiler which is in direct contact with the intense fire of a close range. Other authorities contend that the cold supply pipe should branch into the return pipe from the hot cistern, but here the same objection exists, with another added, for the junction, being subjected to sudden alternations of extreme heat and cold,



is liable to give way. Both these plans are shown in the right side of the diagram. I have seen numerous failures in joints so formed.

The proper method is to connect the cold supply into the hot cistern at the lowest level and opposite the return pipe opening to the boiler, so that the cold water being the heaviest may enter and flow straight across in the direction of the return pipe and down to the boiler, mingling but slightly on its way with the lowest stratum of warm water in the cistern, so as not to enter the hot boiler dead cold, and yet not to intermingle with the upper and lighter strata of hot water in the cistern, so as in any way to prevent the very hottest water being drawn off when required. This plan is shown on the left side of the diagram. The basement hot supplies may be taken from the special base-

ment hot pipe, so as not to affect the hot supply to baths and upper floor hot draw-off taps. And all the hot water supplies to levels above the basement may be branched direct from the upper expansion pipe. There is no positive objection to allow all the hot supplies to the basement and upper floors to be drawn from the one upward expansion pipe. By placing the hot cistern judiciously so as to allow this upward expansion pipe to be given a quick ascending gradient, the water will heat all through to the top by a circulation within itself of the water molecules and by the air and steam bubbles rising through the column of water from the boiler, conveying heat with them; but in some instances it may be necessary, especially where there are long horizontal branches to baths, &c., to induce a slow circulation of the hot water along the branch pipes, so as ensure prompt delivery of hot water when taps are opened. This can be effected by running a small half-inch bow return pipe back from the far end of such branches to the hot cylinder. A definite plan to suit all cases cannot be laid down, each arrangement for each house and all the circumstances require consideration. Abundant opportunity is afforded for the exercise of ingenuity and forethought. The master plumber's practical experience, and his knowledge of the laws that govern the movement of hot and cold water through pipes, will stand his employer in good stead. Ask a dozen men to explain the cause of circulation of hot water through pipes, and ten of them will tell you that the hot water rises because it is lighter than the cold, and they will also tell you that smoke rises up a chimney because the heated air is lighter than the air in the house. But the fact is that neither the heated water nor the heated air rise actively. They are both, if active at all, trying to fall towards the earth, for each have a certain gravity or weight of their own; on each column of heated air and heated water, the attraction of gravitation acting from its centre in the earth is exerting its utmost force, and if left to its influence they would certainly descend towards the earth; but the columns of hot air and hot water, though they do not actively rise, are actively pushed up by the superior gravity or weight of the corresponding columns of cold air or cold water, as the case may be, just as the heavy side of a scale pushes up the lighter side. It is therefore accurate to say that hot water and hot air are forced to rise by the attraction of gravity drawing down the cold water and cold air; and it is therefore inaccurate to say that they rise because they are

lighter. It is important to know and remember this in the practical arrangement of hot water circulating pipes and in the ventilation of buildings and drains.

There is one precaution never to be neglected in arranging a hot water system, for disaster may be the consequence of such neglect. Not an inch of the circulating pipes, supply pipe, or expansion pipe should be exposed to the slightest risk of frost. Remember that the house may be left unoccupied during a winter, and if exposed, these pipes may freeze solid; the fire may suddenly be started, and an explosion occur with results that cannot be regulated. The expansion pipe must always be freely open above the cold water cistern level at the top of the system. I cannot say I care for safety valves on circulating boilers—they charm but to betray. I have found one kind that does not leak, but that always sticks fast, so as to be useless when required. I know another kind that does not stick fast, but leaks so frequently that the possessors at last have expressed a hearty wish to be blown up rather than suffer the misery of having a permanent plumber on the premises, more especially as in the event of an explosion only the cook would be killed. There is another kind formed of a thin diaphragm inside a pipe, carried to a high level, which bursts inside the pipe, and no one knows anything of the rupture, and so this valve becomes useless.

The safety valves of steam boilers are not in contact with water, and cannot, therefore, be compared to safety valves of hot water pressure boilers. If the pipes are duly protected from frost no safety valve is required, but this point undoubtedly is of extreme importance and demands extreme care.

I have already said that all circulating and other pipes when horizontal should be laid on timber supports, having a decided inclination towards the point where any air bubbles may escape, and without any dips or traps in their course. When vertical, these pipes should be secured to timber (previously arranged against the wall or in a chase left in the wall to receive them) by lead tacks or flaps soldered to the pipes about four feet apart and screwed by brass screws to the timber. Iron hooks should never be used without lead slips between the hooks and the pipe to prevent the iron cutting into the lead, but even with the lead slips the pipe is liable to be damaged by the hammer or by the hook being driven too far home, and the pipes will be certain to slip downwards by degrees. Flanged supports or joints on hot water

pipes are liable to cause the pipe to tear across, as no room is given for the irresistible force of the expansion and contraction of the pipes, which in some positions needs more liberal provision than is made for it. I have seen a one-and-a-quarter-inch hot water return pipe tear across three times within a year at a perfectly made flange joint, and I prevented the recurrence of the fracture by cutting away the wood support under the joint where it had been made for the fourth time. The pipe wanted freedom to contract when the water occasionally cooled down. Under no possible circumstances should stop valves be permitted on either circulating or expansion pipes. I am often asked to fix them, but I invariably decline the responsibility. Pipes of every kind should be exposed to view, or arranged so as to be easily seen and handled. We should not be so much afraid of showing good plumbing.

Having now considered, as well as time permitted, the cold and hot water distribution through our house, let us turn to the other plumbing. Soil pipes we are all, I hope, fully agreed should be fixed outside the outer wall of the house, wherever it is possible to place them so, even at a sacrifice of outward appearance. Soil pipes should be carried up full bore for ventilation to some point above the roof where the outlet would be free from any blow down of wind, and away from windows, skylights, or chimneys. In some positions I have found it better to reverse the usual practice, and to make the soil pipe act as the fresh air inlet downwards instead of forming it into the foul air outlet. It is then better to cut the full bore pipe above the water-closet branch rather short, and to provide one or more efficient extracting vent shafts to a high level, to ensure that a constant inflow of fresh air shall take its course down the soil pipe. This plan has the advantage that each time water pours down it helps to accelerate the current of ventilating air rather than to retard it, as is the case when the soil pipe is used as an extracting vent shaft.

Soil pipes must frequently be fixed at the end of return buildings much lower than the main building, and any attempt to make extracting shafts in such a position will end in failure, for the same reason that a stove having its flue built at the end of a return building will always prefer to discharge its smoke into the warm house rather than direct into the air. Even when on odd days the soil pipe or the flue may draw upward, the drain air or smoke, as the case may be, will be blown in at the back windows of the

main house. The plan then to follow is to use your soil pipe as a downward fresh air inlet, and if the stove flues were treated in a similar way, by leading them down and across into the vertical main shafts of the kitchen and other basement fires, they, too, would draw and give satisfaction.

Differences exist still between sanitary engineers as to the best size and material for soil pipes, and as to the best methods of ventilation and trapping. A Glasgow authority states, in his text book, that when several closet pipes are led into one vertical soil pipe the inside diameter may with advantage be five inches.

A London authority maintains in his text book that he has proved by two or three years' experience that three-inch diameter soil pipes may be used with perfect freedom from stoppage, even though several water-closets be branched into them.

The cold of the Arctic north may have influenced the judgment of one to dread the effects of frost on the smaller bore pipe, while the warmer climate of the south may have led the other to fear the results of small water flushes, as required by miserly water companies in large pipes. When I publish my text book from Dublin latitudes I shall follow the style of that more temperate zone, and advocate four-inch diameter as the home rule for universal adoption in soil pipes. My reasons, briefly, are these—Five-inch soil pipes are not thoroughly cleansed by restricted flushes of water, the soil adheres to and dries on the sides, vitiating the internal air; large soil pipes cost more money, and in order to have equal relative strength they should be as much heavier as they are larger than four-inch pipes. They, therefore, occupy more space, look more clumsy, and are more difficult and costly to fix. Three-inch diameter pipes will really cleanse no better than four-inch, because four-inch cleanses perfectly with ordinary three-gallon flushes of water; but, although three-inch pipes occupy less space, and are easier and cheaper to fix than four-inch, yet three-inch pipes are more liable to hold the descending water and soil together in one volume, acting as the piston in a pump, driving all air before it, and sucking out all behind it, and violating the water seal of the traps.

The maintenance of the water seals of traps secure being one of the most important considerations for a plumber, it becomes his duty to see that the size of the soil pipe he fixes shall be such as not to tamper with those safeguards, and I will go so far as to say that although, all things duly considered, I have decided in

favour of four-inch diameter as the best size for soil pipes in general use, yet I would prefer four-and-a-half-inch to three-and-a-half-inch, owing to this risk of syphonage.

While on the subject of syphonage, in passing, let me say that distinct and ample vent pipes should be taken from the top of the outgo of every form of trap on branch soil and waste pipes, irrespective of the diameter of the vertical soil pipe or of its open ventilation above. These may all join one vent shaft to the open air above the roof, or they may be connected into the main vent shaft of the soil pipe above the highest intake branch junction.

Drawn lead is the best material for soil pipes; it possesses smoothness of surface, freedom from corrosion, pliability in bending, security in jointing, and the peculiarity that the material remains valuable even when it is worn out.

The weight of lead in soil pipes should not be less than 7lbs. to the square foot, but though 8, 9, or 10lbs. would pay better in the long run, such good work is seldom ordered.

We are told by our ecclesiastical guides, and we believe with truth, that whatsoever we give in charity shall be repaid to us fifty, sixty, and one hundred fold, and yet, although such dividends are not to be realized in any other investment, we act as if we did not wish to go in for such large profits, and we keep our money in our pockets.

If the public could be induced to expend some of their money in improving the character of their plumbing and increasing the weight of their lead work, they would make a sound investment; but, when the clergy cannot convince, how can I hope to do so. Unfortunately, we both seem to the general public to be interested parties, although our advice is given for their benefit.

Cast iron has also advantages as a material for soil pipes, and ought not to be slighted because we are treating of plumbing; it is cheap, an advantage which tells with the public; it is easily fixed, an advantage which tells with second rate plumbers. The roughness of its surface as compared with lead renders a coating of a solution like Dr. Angus Smith's necessary to fill all interstices and render it smooth. The liability of corrosion renders it essential to cast the pipes heavy, and this extra weight adds to the difficulty of fixing; it is not pliable, consequently the slightest bends must be specially cast, or else lead bends must be introduced.

Branches and junctions are not easily managed in a perfectly secure manner in iron, and often, consequently, lead branches are

used with iron pipes. Iron soil pipes, with lead connections, are not admissible in good work within houses, though the combination may be allowed when placed outside houses.

Now, while on the subject of these joints between iron and lead pipes, let us consider how to make them securely. If a lead pipe is slipped into the socket of an iron pipe, no reliable joint can be formed; if any attempt be made to pack the joint closely with red or white lead, the soft lead inner pipe must cave in and reduce the bore, and moreover, the lead will dry and shrink so as to leave an opening round the joint, whence foul air can escape from the pipe. Here is a specimen of the way a joint can be safely and permanently made between a lead and an iron soil pipe. A piece of brass or copper pipe slightly larger than the lead, and eight inches or nine inches long, has any burrs or roughness of inner edges filed away, and the upper end tinned and prepared in the usual way for a plumber's wiped joint; the brass ferrule is then slipped over the lead pipe, the lead dressed round, and up the end of the ferrule; it is then soldered to the lead, and when the inner surface is examined and found smooth, the brass ferrule end is slipped home into the iron socket. It is then packed round with gaskin, and molten lead is poured in, and the lead gently and carefully battled home with a hammer and calking tool, taking care that no hollow is left in the top of the joint in which water can lodge, and that the pipe is not bulged in by the calking.

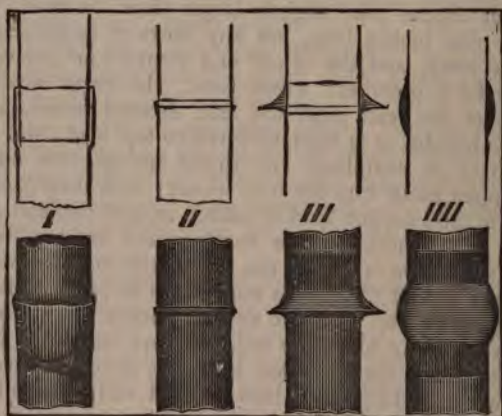
In jointing an iron pipe into an iron socket, gaskin for packing and molten lead for filling are required, and should be well battled home, taking care that the iron socket is strong enough to bear the hammering. In jointing iron or lead soil pipes into earthenware drain pipes at foot, flanges should always be used to grip the cement firmly, and such joints should be made vertically, never horizontally. For jointing lead soil and waste pipes there are several plans which I may briefly describe and illustrate.

No. 1 is a lead slip joint; the under pipe is slightly enlarged to receive the upper pipe, as in a socket; the outside of the inner pipe and the inside of the socket are sometimes coated with thick red lead paint before slipping them together; the joint is then either left to its fate or packed with red lead or putty, and is actually sometimes lapped round with canvas saturated with red lead and tied tightly with bits of twine round the joint! This is the kind of joint with which Dr. Pridgin Teale of Leeds, delights, to illustrate his book on "Dangers to Health," showing sharp

arrows or small devils, I do not remember which, issuing forth in a free and joyous manner, as representatives of the sewer gas coming in to inflict wounds or pinches on the unsuspecting members of the slip-jointed household.

I have found during one thousand three hundred inspections about five hundred slip joints on soil and waste pipes connected with drains, a few being enriched by the canvas addition, and I adjudge any medal that may be placed at my disposal by any sanitary society to this joint as being *facile princeps* the worst and most dangerous of soil pipe joints.

I have here a sample of one of these slip joints on a water-closet



trap taken from a large hotel. You may observe an ingenious device for the purpose of keeping the pipe from parting company with the trap altogether. A lead strap soldered to each, in case the putty failed to grip, I suppose! To make things better, a waste of a bath was defectively soldered to the outgo of the trap, so that hot water could come into play on the joint.

I have here also a sample of a slip joint without either putty or strap found behind a bath casing in a bathroom used by the servants of a nobleman's household, one of whom died from this and similar defects in the fittings. This pipe was the sole vent from a soil pipe of a water-closet under the bathroom, and the soil pipe was directly connected by a drain into a foul cesspool, so that

cesspool air was drawn direct into the house at this point day and night.

In another bathroom of the same mansion I found this bath waste pipe with corroded holes joined into the down of a water-closet trap, also connected to the same cesspool, so that you see the water seal and any foul matter in the trap leaked away and admitted cesspool air here freely also.

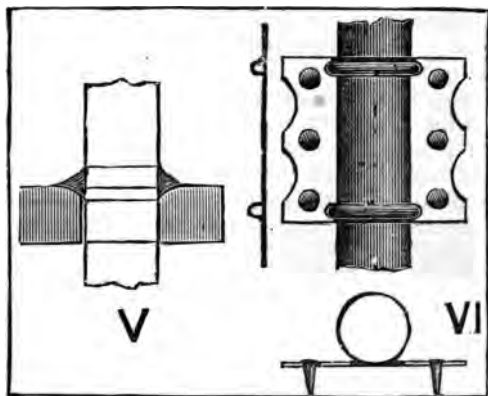
No. II. joint is a poor weak creature, sometimes used by tinmen who set up as plumbers. This joint is made with fine solder and copper bit, and I have seen them made with a blow-pipe, but I shall not waste your time, as no doubt you will condemn them wherever you meet them on soil or waste pipes. I have seen many such joints in my sanitary inspections, but the joint is a good one for connecting brass couplings to lead pipes.

No. III. is a plumber's wiped joint, known technically as a taft joint. I frequently find it on lead pipes, and am fairly satisfied with its strength, though its appearance is suggestive of a little weakness in the plumber's elbows, for it looks, and it is a very easily made joint. The under pipe is widened out as shown, of course, thus rendering the stretched lead very thin; the part to take the solder is shaved bright, and the upper pipe, after being cleaned and shaved, is brought down and fixed in position, taking care to leave no space for solder to slip inside between the two pipes; the solder is then poured or splashed on, and wiped round quickly with the cloth in the usual way, pressing the outer edge of the solder into very close contact with the brightened lead of the taft.

No. IV. is the ordinary wiped joint, which are not so easily made as we might imagine, seeing how rapidly any good plumber will form them and how simply his dirty-looking cloth and clumsy hot iron will turn them out rounded and symmetrical as from a lathe. If a carpenter's character may be known by his tools, a plumber can be judged by his joints. The two pipes to be joined must have their edges made smooth, any internal projection or roughness will catch and retain threads, paper, and particles of matter, and eventually cause a block in the pipe. The under pipe is opened out slightly, just enough to admit the upper pipe about three-eighths of an inch as into a socket, the bore of the pipe being kept full size. Before putting the pipes into position for soldering, the ends of the upper or inner pipe are smudged over to prevent the solder running through and forming inside the joint.

I had a joint made purposely without this precaution to show you the solder projecting inside, but the plumber who made the sample was so alarmed at the result that he carefully scraped away the projection before I could stop him, thus spoiling my good intention. All soil and waste pipes should be jointed with their spigot ends pointing in the direction of the flow.

No. V. is a better joint, and is frequently used where the soil pipe is passing through a floor or wood block, for it is a support as well as a joint. It is known as a flanged joint. The pipe is brought up about one inch over the floor, and a sheet lead flange is cut out to fit the pipe, and is dropped over it. The pipe is then



dressed back over the flange, and the proper portions of flange and of pipe are shaved over and greased. The upper pipe is then duly prepared for soldering and fitted in its place, and the joint is soldered and wiped.

No VI. The astragal joint is ornamental where soil pipes are fixed on the face of a wall. It is often seen in good old work, and there its power of endurance is proved. The soldering is done with copper bit.

In connecting branches from closets, &c., into vertical soil pipe, great care is necessary. These branches are generally made and soldered at the bench, and are there completed *when possible* with the water-closet traps attached ready to lift

into position. These branches should never be mitred into the stack pipe, as it is almost impossible to make a mitred joint without leaving internal projections. An oval hole should be cut in the stack pipe, small enough to leave plenty of lead for dressing out into a neatly-formed socket, into which the branch pipe will accurately fit, entering about one-quarter or three-eighths without reducing the bore of the branch, and without entering within half an inch of the stack pipe bore. No projection of any kind inside the pipe or joint must be allowed to remain, and previous careful fitting of the joint will prevent solder getting in. The usual width is neatly painted with smudge round the socket and round the branch, and the parts are then shaved bright and soldered, working the solder well round with the cloth, as it is liable to keep slipping off, and managing, as practice alone can explain, to keep the pipe and solder hot and workable until a solid symmetrical joint is wiped. Of course no branch should be allowed to enter a vertical stack pipe at right angles. It should always slope towards the vertical pipe, and the socket itself on the stack pipe is dressed so as to present a smoothly-rounded curve for the soil to glide over from the branch pipe. The more sharply inclined is the branch pipe the greater tendency will there be to syphon out the trap, therefore it is not well to give any greater incline than is necessary for clean flushing of the branch pipe.

When flanges or pipes are shaved and greased on the bench in order to solder them in position, it is safer to tin them over on the bench, because any lime or dust getting on the grease would spoil the soldering, and might destroy the joint. It is also desirable not to let solder be spilled about and wasted in joint making, and consequently a set of flanges of lead should be always cut ready to clip over the smudged part of the lower pipes under the part to be soldered, not only to catch the dropping solder, but to help to keep the pipe hot thereby during the process of wiping the joint. These flanges should of course be kept well smudged over to prevent solder adhering.

Solder for plumbers' use is best when made from pure soft pig lead and good pure tin, the proportions are generally two of lead to one of tin, but I prefer a little more tin, say, 36lbs. of lead to 20lbs. of tin for each cast, and then add a little lead when melting, if for making underhand joints. Pure sheet lead clippings are always at hand on a plumbing job, whereas, if the solder be made coarse, pure tin must be served to the plumbers to enrich it, and

it is better not to have tin lying about loose in premises. Lead melts at  $612^{\circ}$ , tin at  $442^{\circ}$ , plumbers' solder at  $441^{\circ}$  Fahrenheit. It is therefore difficult to wipe joints on tin-lined lead pipe without causing the tin inside to melt and run. Fine solder copper bit joints are better for such pipes.

When an underhand joint comes to be made, the lead is poured over the smudged part of the pipes to get up a heat, and then gradually the stream of solder from the ladle is dribbled over the shaved part and is drawn round and round the joint by the hand with the solder cloth. The lead is dribbled on to the edges of the joint next the smudge, and is worked by the cloth towards the centre of the joint from underneath to the top. Special care should be taken to wipe the solder well on the under side of the joint, as it is liable to drop away. I notice that the best plumbers convey the hot solder direct to the bottom part by dropping the solder on their cloth held under the joint right and left alternately, dragging the solder from the bottom round to the top, and forming a bulb of solder all round the joint which is then well worked with the hot iron, and finally finished by wiping smooth. A good joint maker would have a joint made while I am describing one.

I do not think joints should be too short nor yet unnecessarily long. There is a happy medium; a three-inch or two-and-a-half-inch joint gives all the strength needed for a four-inch soil pipe.

Upright joints are sometimes made by pouring on the lead from the ladle, and sometimes the lead is splashed on with a splash-stick. The hot lead should first be applied close to the upper smudge line and kept pulled up, as it falls towards the bottom of the joint. The work needs doing rapidly, and when the joint is roughly formed, the hot iron and solder cloth should work round and round the bulb and along the edges of the joint, the cloth pressing the solder into close contact with the pipe, especially at the edges, and forming a symmetrical joint as sound and true at the back as at the front. It is for these upright joints that the lead flanges to collect the solder prove of use.

The bending of lead pipes needs as much skill and care as the jointing of them. Almost any shapes may be given to lead, but bends are not any better for being made sharp, the gentler the curve, as a rule, the better. The difficulty of bending pipes is in preserving the bore full size throughout, and in keeping the thickness of the lead equal. Take a piece of lead pipe, heat it, and

slightly bend it, of course the lead will thicken at the inner neck and attenuate at the outer heel, while the section flattens and bulges sideways. The object of the plumber will be to coax the thick lead round to the thin part, and it is in doing this well that his skill appears.

Cast bends are now obtainable so perfectly made that pipe bending is not so frequently necessary. The workmen I have contact with hold a theory that cast bends and traps fail where hot water is much used, but I cannot say I have noticed this result in practice, and I use cast bends and traps without any fear of failure, but they sometimes run thin in parts and have air holes in them, two very decided faults which make the continuance of the hand made bends and traps possibly desirable. Bends and traps made with wide seams of wiped plumbers' solder, though more clumsy, are stronger than with fine soldered seams.

Time does not allow me to describe the lining of cisterns and troughs with lead, but I may just say, let the lead be strong, and allow no nails in the corners under solder joints.

When connecting branch pipes from inside a house into an iron soil pipe outside the main soil pipe should be fixed to one side of the hole whence the branch issues, and a bend on the branch should be turned toward the main stack, so that the joint may be made in the open air. It is then safe to use a cast-iron junction piece, but it is not safe to form this joint in the thickness of the wall. The soil pipe should be carried up full bore to the level of the ridge of the roof, and have a fixed extracting top to induce upward and prevent downward currents, except in some cases, where it may be very advantageous to arrange the soil pipe as a fresh air downward inlet to supply the current of air to some more lofty extracting ventilating shaft, as already mentioned. It is not possible to lay down strict rules applicable to all cases. The sanitary object to gain by any and every sound means is to provide for and maintain a current of constantly changing fresh air through every foot of soil pipe, waste pipe, and drain, with discharging end at a safe distance from windows, skylights, or chimneys, and with the air inlet arranged so that no offence may be caused by chance back draughts. All branch waste pipes should be abundantly ventilated from the outgo of their respective traps and by a vent pipe distinct and separate to over the roof or into some point of the main vent shaft of the soil pipe above all branch intakes. It has been clearly proved that this precaution is necessary, not only

to maintain the movement of air through pipes, but also to prevent the danger of the violation of the water seal in the traps. The best forms of traps for various purposes requires so much consideration that the subject could not be dealt with in one lecture. D traps, Eclipse traps, Helmet traps, Anti-D traps, Roundway P and S traps, Banner, Buchan, and Bower traps afford a rather puzzling choice to the plumber. The points I look for in a good trap are these—A small internal surface, and every portion washed by every flush, total absence of sharp corners or edges, a good water seal yet easily cleared by the smallest flush, an open air space between the inlet and outgo sides, and of a form to resist syphonage when properly guarded by ventilation. Undoubtedly the D form of trap is not self-cleansing, and although it is the last trap in the lot to have its water seal violated by syphonage, yet it presents an internal surface of about four hundred square inches, usually coated with foul slime and filth, and you can see, by examining this trap with glass sides that no amount of water flushing can cleanse it. I have brought over with me a real old Irish D trap to introduce to your notice. It was removed from under a water-closet in the centre of a nobleman's mansion, where, strange to say, attention was drawn to it by a strong smell! The trap, as you see, is slightly the worse for wear; it has not at all an aristocratic appearance; in fact, it is falling to pieces so fast that my evident anxiety about the way it was handled in transit nearly got me into serious trouble with the detectives at the railway, who evidently considered it was a dangerous explosive; it certainly looks very suspicious. The deposits found in these old D traps vary from three to eight pounds in weight, and thousands of them exist in the best mansions of Great Britain. They are called traps, but being innately filthy, they keep the word of promise to our ear and break it to our nose.

The greatest danger of all traps formed on this model, having the dip pipe concealed inside, whether D trap, Eclipse, or Helmet shape, is that there is no air space between the inlet and outgo, so that if any hole is corroded or made in the dip pipe foul air has free entrance, the water seal no longer acts as a check, and the dangerous defect may remain undetected for years.

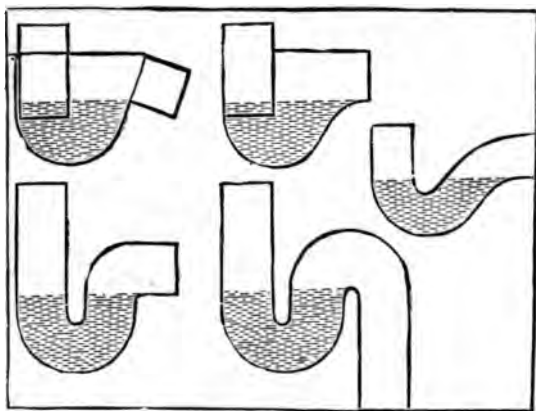
The ordinary round way trap, if well made, as all things should be, and of the U form, shown on diagram, not that with the sloping outgo, seems to me to have everything to recommend it when efficiently ventilated; it has a small surface, small contents,

is self-cleansing with small flush, has no corners, and is easily made, easily fixed, and cheap.

The Anti-D trap I believe to be a good form. It has been greatly praised, but the ordinary well-made round way trap is, in my opinion, quite as reliable when ventilated aright

All these traps may with advantage be slightly reduced in bore at the bottom of the syphon, and enlarged at the top of the outgo; the flushing water will always be thrown up against the enlarged bend to cleanse it, and the enlargement at that point lessens the tendency to syphonage.

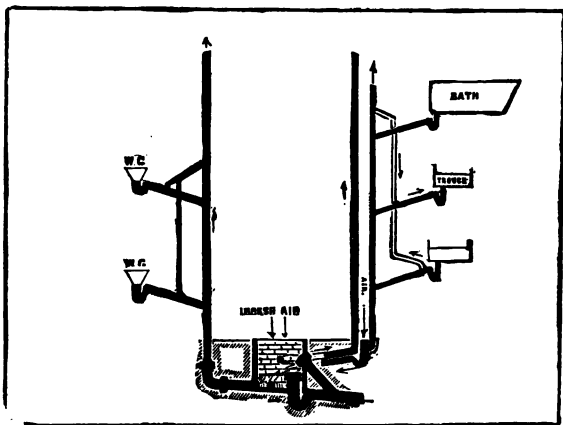
The best dip or drown for the trap of a water-closet is from one-and-a-half to two inches, the latter is best where water flush



is abundant. Trough, bath, and basin traps may vary in the depth of dip, according to circumstances, from three to six inches. Slop sink traps may have from two-inch to three-inch drown.

Every trap should be independently ventilated from its own branch pipe a few inches beyond the outgo, so that foul water may not be splashed up into the vent pipe, and the vent should be made as large as the waste pipe, or as nearly so as can be managed. Every trap of basin, bath, trough, or sink should be fitted below the drown or water line with a brass cap and screw soldered in for cleaning and clearing. Water-closet traps do not require this precaution. Bell traps of all forms are worse than useless. Traps

with check valves, or balls, are unreliable, and, moreover, such precautions as they are vainly supposed to furnish are unnecessary where a proper disconnection from drains is carried out. I assume in all my remarks that thorough disconnection of all house pipes from the drain has been effectually carried out, and though the subject belongs to drainage, not to plumbing, I may say that the best system is that of built manholes, with open grooves crossing them from the open ends of the house pipes, and leading into the interceptor trap, which should also be in the chamber for easy inspection and cleaning, and abundant fresh air ventilation to the chamber provided either by an open grating or by large bore open pipes.



Now with regard to the best form of water-closet apparatus to adopt, I confess that I am undoubtedly prejudiced in favour of a perfectly simple form of all-porcelain which I had made for my own house many years ago, and found so safe, cheap, simple, and effective that I have recommended it everywhere since. I believe it is adopted by other makers, or something of the same kind, but except in work under my own control, I do not see it coming into use. It is so simple that it could hardly be patented, and some people do not think anything can be worth anything now-a-days unless Her Majesty has been asked to stamp it with her Royal

approval in Letters Patent. I know that by adding a few valves, levers, cogwheels, and endless chains it would be appreciated better by many. The judges at the Dublin Sanitary Exhibition were so surprised at its efficiency that they decided to have one fixed in London for special tests to be applied. The only complication about the apparatus is its name—The Gold Medal Sanitary Reform Closet. Care must be taken to connect the porcelain flange of the trap in a reliable manner with the ventilated soil pipe, which is dressed over as a wide flange on the floor or step to receive it, and is dressed up round the stoneware flange and screwed down tight by screws to the floor through an iron ring above the lead flange, bedded in red lead. If this joint be as carefully made as a plumber's joint ought to be made it is as safe and will stand as well. This water-closet has the unique and important advantage that the trap and the water in it are directly visible, and that the moment the flush clears out the paper and soil from view they are swept away, not into another trap beneath out of sight, as is the case in many other forms of apparatus, but away from the premises never to return.

Pan water-closets, valve closets, washout closets, and others may, instantly that the handle is pulled, remove the soil from sight, but though lost to sight, it may be to memory very dear indeed, for the trap beneath may, and often does, retain the soil for days, or at all events until the next usage of the closet, when, although the retained deposit may be forced to move on, another is left in its place.

The trap is made deep enough with a three-inch down, deeper than usual, to show a good depth of water lying up in the basin, guarding it from pollution and resisting syphonage and evaporation. The basin has a flushing rim so formed as not only to wash the sides, but to drive the paper and soil out at each flush. A ventilating socket with brass union on the outgo, effectively prevents syphonage in conjunction with the main vent shaft on the soil pipe. The trap is formed with a wide funnel, which receives the basin. The basin dips into the water of the trap, and if the basin be broken by accident it can readily be replaced. The trap being over the floor and above the lead safe tray can be guarded from frost and easily cleaned, repaired, or renewed if necessary. Care is required in adjusting the service pipe so as to give the water a proper direction and force to drive the contents of the basin before it at one flush. One-and-a-half-inch service

pipes are desirable, and the valve in the cistern should be two-inches in diameter. The two gallon Water-Waste-Preventing Cisterns, for preventing the sufficient cleansing of closets, soil pipes, and drains, can be attached to the Universal Closets with results nearly as dirty as when they are used with the ordinary apparatus.

The Washout Water-closet is a fairly sanitary form of closet, but it does not always cleanse as well as one would desire, and I have noticed paper and solids remaining partially concealed in the trap for a long period. It is not to be condemned, however, in any respect, and is a great improvement on other forms in general use.

Trapless closets of all sorts and kinds I utterly abhor and condemn. The valve water-closet, if well made, is a very good apparatus, but when really good is costly, and must be reserved for high class work. I do not like it as well as the simple porcelain form on account of its many complications, its hidden lead trap, its metal valve box, its overflow pipe and overflow trap seldom deep enough to prevent violation of water seal, its valve often letting the water in the basin drain away and leaving it dry and empty. But when a good valve closet is well fixed and ventilated from its valve box, as well as from its trap, it is really good.

The Twin Basin and all Plug Valve Water-closets get very filthy in parts of them difficult of access, and they, too, have complications and weak points, and are losing ground with sanitarians.

The Pan Closet I need only mention to condemn as the dirtiest form of closet apparatus, and with its D trap, the evil genius of the unfortunate plumber.

Then we have all the patent closets of all the patentees, as numerous as the sins of the human race; all exhibited, advertised, and certificated; all costly and many faulty, owing to their invaluable complicated improvements; but, with the reticence of our old friend, Mrs. Sairey Gamp, let us "name no names."

I recommend cistern valves and conical service pipes for closets in preference to valve arrangement under the seat, with or without the air adjusting bellows regulator known as Underhay's. With Underhay's valves the service pipes are always full of water, and liable to burst in frost, causing grievous flooding and damage, and rendering the closet useless for a time. With cistern valves the service pipes are empty and unaffected by frost. Good cistern valves give very little trouble, while valves under closet seats, being

under constant pressure, are liable to leak, and unless large do not give sufficient flush.

I prefer the flushing handles of closets, where possible, to be arranged on walls to pull down rather than fixed in the seat to pull up. Cranks, wires, and levers are thus abolished, and the seat having no recesses is easier cleaned. A lead safe tray, turned up four inches, should be fixed under all closets, with a one-and-a-half-inch lead waste pipe to open air, with a light copper hinged valve on the outer end to exclude cold air currents. This waste should not be carried into the soil pipe or trap of the water-closet under any circumstances; it is a common and very dangerous connection. The closet should be arranged so as to prevent any chance accidental drip from it if out of repair, polluting any cistern on a lower level. There should be an indiarubber tube attached either to the underside of the seat or the upper side of the basin of all closets, to make a yielding but air tight connection between the seat and the apparatus. The seats and fronts of all water-closets should be framed and hinged, so as to open quite easily, and to close and fasten with a simple catch. Water-closets should never be fixed in dressing-rooms. Water-closet compartments should never be in the centre of a house. They should be specially arranged with large windows, easily opened, and tight-fitting doors; where possible they should be built out from the house, and with a thoroughly ventilated vestibule between the closet compartment and the house. The compartment and vestibule should be warmed in winter above the house temperature, and so arranged that the current of air should flow from the house into the vestibule, and not from the vestibule into the house. Vertical ventilating inlet tubes are sometimes useful in closet compartments.

Water-closet cisterns should invariably be kept well within the closet room, and should not be cased in with timber till the plastering behind, beside, and above is made absolutely perfect and air tight. The wood front casing should stop a foot short of the ceiling, to enable the plaster of the ceiling over the cistern to be always seen, so that the least breach may be noticed and repaired, to prevent smells ascending from one floor to another.

The very greatest care should also be observed in rendering the plastering complete behind the closet seat and skirting, and behind any casings in the water-closet compartment, for annoyance and even illness has been often caused by neglect of this precaution.

The floors of water-closets also should be absolutely air tight, and the plaster should be carried down to the floor before the wood skirtings are nailed up.

Tiled floors and tiled skirtings and tiled walls are most desirable in every closet; if these cannot be obtained, oil painting should take their place. Walls, floors, and skirtings should be impervious and washable, and I will add—washed.

The housemaids' slop sinks are very similar in character and purpose to water-closets, and I will treat them similarly, connecting the waste into the soil pipe of the water-closet, if convenient, and if a separate waste would prove too costly or increase the number of waste pipes over much. The slops thrown down these sinks from bedrooms cause odours which require dealing with in the same manner as the soil passing through the water-closets. The waste pipes, therefore, of slop sinks should never connect into the bath or basin wastes, pantry trough wastes, or any such comparatively clean waste pipes.

Each sink should be provided with a cleansing or flushing pipe and valve, so that every part of the sink can be cleansed with water, but so arranged as to prevent cans or tumblers being filled thereat. It is very unsafe to fix, as is commonly done, hot and cold taps for bedroom uses over such slop sinks. Slops, when being emptied, are frequently splashed over and contaminate these taps, and illness may be caused by the use of water taken from such contaminated sources for filling bedroom carafes. Draughts may be drunk from these at night by thirsty sleepers barely aroused, and their energies being dormant, offering little resistance to the attacks of disease. Such sinks should be kept scrupulously clean. I prefer them conical in form, of white glazed stone ware, with three-inch leaden traps, well and separately ventilated full bore three-inch, and a three-and-a-half-inch waste pipe outside open full bore to roof, the same as soil pipe. These sinks are sometimes made of enamelled iron to resist the pressure of cans or jugs rested in them by servants when filling, but if the taps for filling cans are elsewhere no strain will be put on the sink, and white stoneware is cleaner than iron. I also prefer the cover and skirtings of the sink formed of enamelled earthenware in one piece, as I have had them specially made. They are purer and better than tiled backings. The casings are sometimes made of enamel slate in five pieces, but soil gets into the jointings and may cause a smell. Lead is strong, but not clean for such a purpose.

A white enamelled earthenware trough should be fixed beside and above the slop sink, and free from all chance of splashes from the sink. The waste and overflow should be discharged over the slop sink, not into any pipe or drain direct, and the hot and cold water supply taps for bedrooms may be fixed at the back of the troughs, high enough to leave room for cans and jugs to stand under while filling.

Enamelled earthenware troughs, with earthenware high backs, save the trouble and expense of lead flashings; they are made with holes prepared for the taps to come through. The overflows are formed in the earthenware itself, adjoining the waste. Gun metal plugs and washers with gratings are fixed over the waste, which is discharged over the conical sink. These troughs rest on timber stands or on wall brackets, and I think are cleaner and more wholesome when not cased round with timber.

Pantry troughs, in which glass and china are washed, will be best made of timber lined with tinned copper, and a high back or skirting of the same (having a hard wood coping round the edges as a neat finish). Hot and cold water laid on from a perfectly pure source, as decanters and water jugs may be replenished here for drinking use. The waste pipe may be one-and-a-half or two-inch lead pipe, with a lead trap and brass cleaning capscrow, and the waste pipe delivery in the open air free from all contamination, a one-and-a-half or two-inch ventilating pipe being also led from the outgo of the trap to prevent risk of violation of water seal of trap. The vent shaft of the waste pipe need not be carried to the roof level, but may be ended and left open two feet above the junction outside.

Lead is also used frequently for lining pantry troughs; it costs less, but is not so clean as tinned copper. I prefer white enamelled earthenware or wedgewood ware for its greater purity to either copper or lead, but the danger of breaking glass and china when washing renders the use of a wooden bowl or tub placed inside the sink a needful precaution, and this is sometimes considered troublesome.

Dairy troughs should be always of porcelain or enamelled earthenware, and the waste pipes must be most carefully disconnected and ventilated, and the water supplies rigidly pure. Milk and butter are most readily and dangerously tainted by bad air or impurity of any kind.

Laundry troughs are now made in white enamelled earthenware, better, cleaner, and more durable than any other material.

Scullery sinks are best made of tinned copper, and next best of enamelled earthenware. They are also made frequently of timber, lined with lead; in that case the lead cannot well be too heavy—not less than 16lb. bottom and 12lb. sides for good work; flashings may be of 7lb. lead, and the drainer of fluted cast lead. The trap in any case is best made of 8lb. or 10lb. lead with cleaning screw and waste, and the overflow should be safely delivered into the open air or into a disconnecting grease trap in the open air. The practice of placing iron or other grease traps under the sink inside the scullery I have always found most objectionable. While such traps are undergoing their quarterly cleansing the smell in the house is really too hard to bear; "it makes me tired," as our American friends say. Water supply here should also be absolutely pure. I must not go beyond plumbing to speak of drains, but how to keep scullery drains free from grease is a subject for a lecture or two.

Seeing too often the terribly careless manner in which ordinary drains are laid, I have taken much trouble to bring them more directly under the plumbers' ken, and I have had patterns prepared and made, cast iron six-inch and four-inch drain pipes and connections of every kind and size, and I have made arrangements with Mr. Buchan to make his patent traps, access pipes, and grease interceptors all in cast iron, the joints being formed of lead, so that the plumber can lay and fix all the pipes and drains connected with the house, and decline to share his responsibility therefor with any man in future. I strongly approve of cast iron drains wherever the drains must be laid under houses, but I would need time for another lecture to deal with that subject.

On the important subject of baths and lavatory arrangements, time does not permit me to speak, except to insist on the absolute disconnection of their waste and overflow pipes from all drains and foul pipes.

Sanitary plumbing is by no means an easily acquired art; many years of diligent training are needed for its mastery, either in theory or in practice, yet, strangely enough, every kind of trader seems to think that he may add plumbing to his list of acquaintances without any decent introduction.

There is hardly a house painter in England who can resist the temptation to add "Plumber" to his signboard while his brush is in his hand. This conglomeration of trades is one of the strange characteristics of our time, and we need not waste energy in trying

to stop its progress; all are compelled to submit to it, and none of us can tell how far it will go.

But if there is one handicraft more than another which will burn the fingers of an untrained man, or in which he may take up the wrong end of a hot iron so often, that handicraft is plumbing.

Now, a plumber may undertake house decoration, and produce some startling effects of colour or design in a dwelling house, but his frantic struggles after the old masters do not destroy human life, though peace of mind may be annihilated for a time. But when a decorator or a linen draper ventures into plumbing work, he may frequently poison whole households, perhaps slowly but surely, so that he may safely venture to add on the undertaking business also, with a prospect of success.

I remember well the first sign of the union of incongruous trades in my district, as it startled us all. Our chimney sweep—a most estimable and honest man, “black but comely,” and moreover an excellent chimney sweep—finding that he could spare half of his little shop window, made all the necessary arrangements, and boldly added the sale of butter to eke out an improvement to his regular income.

I allude to these facts not with any hope of changing the current of events, but rather to point out one of the causes of the bad and dangerous plumbing work now so often found during sanitary inspections, and in the hope that those employers who, in order to increase or keep up their returns, take upon themselves the serious responsibility of plumbing may endeavour to realize the greatness of that responsibility, and may at least see that they learn something of the science and practice of a handicraft which so closely controls the concerns of life and death. The character of modern plumbing is also sadly debased by the manner in which such work is let out in competition to the lowest bidder.

I hold that the sanitary plumbing and drainage of a dwelling is of such paramount importance to the safety of the lives of the residents, that it should never be included in the builder's general contract nor put to public competition. Trade competition, or throat cutting as it is developed latterly in plumbing and drain-work, lies at the root of scamped workmanship.

Take one instance. Competition estimates are publicly invited for the plumbing and drainage of a large boarding-school ninety miles from town. The fair value of the work is £260. Six contractors attend and pay £1 each for copies of specification.

They have then each to pay rail and car fares, to spend one day at the building, and another day over the estimates, each man knowing that his chances are five to one against him, and that five of the six men must lose their time and money—not a very cheering encouragement to a hardworked, busy man. Tenders are sent in £280, £260, £240, £220, £190, £130. The lowest is accepted. The contractor soon finds he is going to lose, and accordingly “contracts” the weight of material and hurries on his men, scamps his work where he can, makes no suggestions where he sees improvements desirable, lest he add to his loss, and tries in every way to get out of the unfortunate job with as little loss as possible. But the contractor who gave the fair estimate, and who should therefore have the best claim to get the work, is left to bear his loss of time and disappointment with a clear conscience, but with a sore heart, when he sees his competitor probably passing soon after through the bankruptcy court, paying 5s. or 10s. in the pound, and coming up fresh at the next competitions to cut the honest and capable contractor’s throat once more.

There is no reason that I know of (except the national epidemic of “the sin of cheapness” at present raging) to prevent the general adoption of some just and honest method of arranging or contracting for plumbing work. For instance, select carefully the master plumber you wish to employ, making due enquiry into his character and experience, and inspecting some of the recent work by which his character was formed and his experience gained. Invite him then to call on your architect, who should explain to him that he is asked to confer and consult as to the plans and specification of the drainage and plumbing of the building in question, to offer his suggestions freely for consideration, and to give a detailed estimate of the prices at which he would undertake the work, on condition that the architect should then examine the estimate, and that if in his opinion the estimate is reasonable, that then, without competition, the work should be entrusted to that master plumber; but that, in the event of the estimate being considered too high, then and there the matter should end, and the architect be at liberty to seek another contractor.

I have experienced the practical success of this method, and if it or some better plan were universally adopted, we should soon see an end of scamped work. Masters would emulate each other to justify the confidence placed in them. The wretched work, produced by men whose estimates have been forced down in

competition necessarily under the actual cost of proper work, and the starvation contracts and bankruptcy competitions would cease to debase the handicraft of plumbing as they are doing now.

Fair profit in business or in handicraft seems often now-a-days to be considered and treated by the wealthy as a sin worthy of disgrace and even punishment, so that such profit is becoming less and less every year; but let us say this word in conclusion, the day that sees fair business profits swept away by competition or any other means will be the very worst and darkest day that England as a great commercial nation has ever seen.

If I have occupied too much of your time to-night in this address, I beg to apologise as earnestly as I wish to thank you for the patience and attention you have so kindly given to a stranger. The subject is, as I have said, too wide and too important to deal fairly with in one lecture. Though I have been a quarter of a century an employer of plumbers, I am sorry to find how little I have been able to say to-night in the time at my disposal of all that I have so much at my heart.

I know well I have the honour of addressing many here to-night from whom I would most gladly receive lessons either in the theory or practice of plumbing, and who are well fitted to lecture me, and that I am indebted to this important Sanitary Association for the honour of their invitation, not so much to my long experience in the advancement of Sanitary Reform in Ireland, as to their wish to know what a sanitarian might have to communicate from his labours in that distant and dangerous island, where the Annual Congress of the Sanitary Institute of Great Britain had lately assembled.

The apathy which distinguishes the English householder on all sanitary home subjects is equally marked in Ireland; disease and death find easy access to the home through plumbing defects there as here. Parents who would lay down their lives cheerfully to save their children let them sicken and die in their arms, and children, too, are made orphans because of the prevailing ignorance and neglect of Sanitary Reform.

At Kidderminster thanksgiving services were recently held in state for the abatement of a typhoid fever epidemic—an epidemic that has blighted the happiness of many homes, and left many sad, sad marks of its effects—an epidemic surely not caused by the act of God, but by the ignorance or carelessness of the citizens themselves.

It seems as reasonable to expect preservation from burning if we enter a fiery furnace and sit down in it as to expect that ourselves, our wives and children, shall be preserved from the dangers and diseases due to contaminated water and foul drain air where we live, move, and sleep in dwellings, into which these evils are freely admitted through dangerously defective drainage and plumbing.

Seeing, therefore, that bad and insanitary plumbing is an easy channel through which disease and death, suffering and sorrow, may enter the homes we are bound to protect, let us do all in our power as Sanitary Reformers—with our hands and arms if we are working men, with our minds and tongues and pens if we are thinking men, and with our money if we are rich men—to hasten on that bright day when, in our English, Scotch, and Irish homes, we may fairly boast of the blessings of Universal Sanitary Plumbing.

# DECORATION AND FURNISHING.

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BY G. F. ARMITAGE, ESQ.

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WHEN I was first asked to speak to you on the furnishing and decorating of a house viewed from the healthy point, I must own to feeling slightly puzzled. I wondered whether the Committee would expect me to treat the home as a fever hospital, and caution you against the use of carpets, wall papers, or curtain hangings, against comfortably upholstered furniture, or in fact anything that could not be turned out of doors on a moment's warning and scoured down with soft soap and water.

If this be what is expected of me, I cannot say much more than advise you to have your various articles of furniture well made, of the best and hardest timber, that they may be strong enough to stand this hard and trying life. Avoid colours that will not wash; never put two kinds of material together that stand a chance of shrinking or fading differently. Let none of your furniture be glued together, but firmly screwed and pinned, as you would make a boat. Use no paint, polish, varnish, or other finishing material that will perish in the wash, but let all your woodwork be hand polished with one of the best antiseptics you can use—bees' wax and turpentine.

I would advise you, especially as I suppose I am expected to speak on this question from an artist's point of view, to select the most cheerful light-giving colours, and combine them in perfect harmonies. Be sure that few things are more injurious to health—especially the health of the mind and the eyesight—than dark, heavy, inharmonious colours, and combinations of strong opposites. The presence in your rooms of masses of black and white in juxtaposition, and such crude arrangements, are calculated to affect injuriously both the mental and physical eyesight.

Doctors will tell you how much people of weakened intellect are influenced by their surroundings of colour; how the madness of a wildly excited lunatic is increased when left in a room with a red paper or red blinds, and how, if taken to a room the colours

of which are blue, he will sink into comparative quiet. Another melancholy lunatic can be cheered and helped into a sounder frame of mind by living in red and yellow rooms.

Now, as we are told that we are all insane on some one point or another, it behoves us carefully to examine ourselves, and discover if our madness be rampant, quiescent, or melancholy, and so arrange our immediate surroundings as best to meet our several cases.

In this dull smoky climate of ours men are generally found suffering from depression. Speaking of those whose work compels them to dwell in, or very near to, large centres of industry, I do not think the poor suffer more than those who are better off. In a very short time the soot, dust, and grime reduce all colours to a dull monotonous grey. When visiting the great cities of the South, where the air is bright and clear, where there is no coal smoke to defile it, and all colours are intensified by the brilliancy of the sunlight, one is struck by the brightness and gaiety of the people, even of the very poorest classes—far poorer and more destitute than any of the same class here. I would maintain that colour in the light and surroundings are solely answerable for this, and that if you could bring a number of these people, say from Florence, and put them down in Sheffield, Birmingham, Newcastle, or even in Manchester, and allow them the equivalent of work, wages, and warm clothing, and in fact guard them against any injurious difference to their home surroundings, except the change of colour and light, that before three months had elapsed they would succumb to the baleful influences, and not being inured as we have been, one half of them would be in the asylum.

You have seen the face of the Italian organ-grinder in winter. My particular madness is of the melancholy type, and so I paint all my surroundings in bright and warm tints. The walls of an enclosed yard where I live I have painted a bright brick red (the good brick colour had previously been destroyed by whitewash). Twice every week a couple of Italians wheel their piano-organ into this enclosure and play for me. The change that comes over their faces while under the influence of this colour is most marked. While one turns the handle beaming (not the hideous grin of expectancy, but the beam of a satisfied sensation), the other will roll and enjoy his cigarette. These men, when seen pursuing their daily round amongst the dull flat coloured residences of the district, are as sad and melancholy as an organ-grinder can be.

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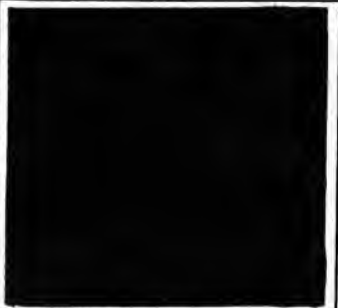
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## GOOD SHADES OF COLOUR.

Reds and Yellows that will harmonize with Brown.



lose the power of detecting reds and yellows if you used no other colours to compare them with.

I show here in Fig. 1 a coloured sketch how to use the various tints in the decoration of a cornice, the colour scheme of which is red. You will observe I have employed several shades of green and of blue; it is true these colours do not here appear in their brightness, they have been much alloyed by an actual admixture on the palette before being applied of some of each of the other tints. The reason of this I will explain to you directly on the blackboard. You will observe the effect these light lines of green and blue have; they divide the reds and yellows, giving power and value to each in the composition. If I had employed one of the colours—the brown, green, or red—of the paper, and tinted my cornice merely in shades of it, I should have formed a distinctive band of one overpowering colour, too powerful and massive to harmonise with the well-balanced scheme of colours, as shown in the paper. It would have become in the room the one object of striking importance, and would so have destroyed its harmony or restful repose; and would have been as much out of place with this many-coloured paper as the rich cornice would have been in a whitewashed cellar.

It is possible you may incline to this second notion; many people do so at first; but I feel certain that you would discover, after careful thought and observation, that in the varied colouring there exists a harmony which cannot be obtained with the use of shades of one colour only.

In the decoration of a room great care should be taken that no colour or object forces itself on the attention, except it be the one worthy object round which all interest centres. Even it must be modest. But the actual decoration, *i.e.*, the painting and papering, with which we are now dealing, being, as it were, the mantle covering the skeleton of the room, must form only the background against which all other objects stand, and it must be placed there with the kindest consideration for these objects.

Being, therefore, anxious that our walls shall not force themselves upon the attention, reminding us of the narrow boundary of our rooms, we must treat them in colour, together with the ceiling, cornice, and woodwork, just as Nature out of doors treats her landscapes.

Her colours are pure, not half tints, and so some people tell us ours ought not to be for indoor work, but they forget the impor-



CEILING.



CORNICE.



WALL PAPER.



tant item, not present indoors, of atmosphere, the kind veil Nature draws over crudities ; and they forget also this, that every colour in a landscape is softened to the eye of the observer by its next door neighbour ; that from every inch of the mile of landscape he is examining, some different ray of colour is darting to the retina of his eye, and so producing on his senses the effect of colour we endeavour to imitate in these so-called half tints

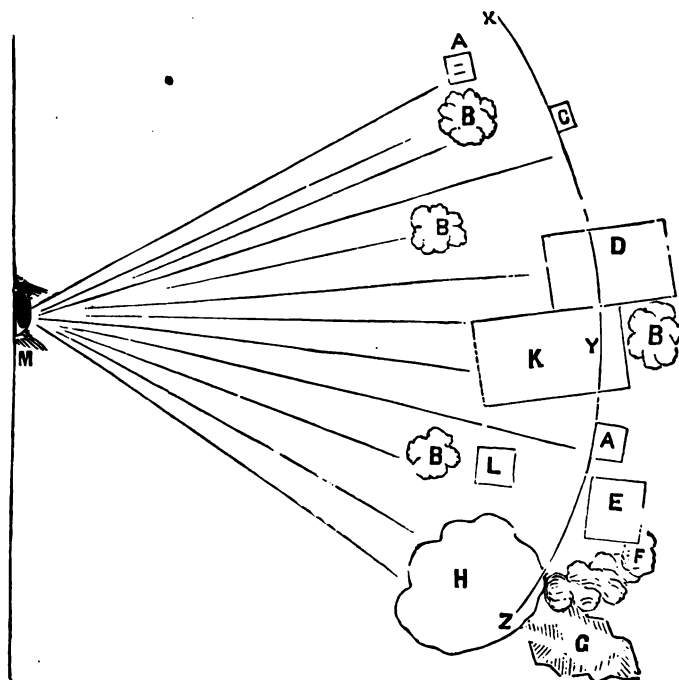


Fig 2

Fashion has done a great deal for us lately, and we see all the shops full of lovely colours. I only fear their mixing them to such an extent that we shall require some delicate instrument to detect one from another.

In this diagram (Fig. 2) I endeavour to illustrate the meaning of my argument. At the point M is the eye of the observer, and

the line X Y Z shows the distance at which he has focussed his sight. At the point A we will suppose bright red houses, sending their red colour rays to the eye; at B there are various clumps of dark green trees sending their rays also; at C, when closely examined by a telescope that excludes all rays from arriving at the eye, save from the one point, a staring white house. D and E represent fields of bright corn, and K is a ploughed field, while H stands for a small lake sending countless rays of colour—dark blue, light blue, and white—from its rippled surface, that, striking the eye, soften most effectually all harsher tints lying near.

You must also imagine how from every other point in the landscape lying between the eye and the sight line X Y Z, countless rays of colour are helping to tone one another, and the hue of the particular thing the observer is attempting to see.

Now, we must learn experience from this, and let it guide our practice when we attempt to decorate our rooms, so as to make of them *healthy* abodes. For a moment, I will return to the coloured cornice, Fig. 1. When I painted this I put on my palette some white paint; three kinds of yellow, raw sienna, yellow ochre, and chrome yellow; two blues, Indigo and Prussian; three reds, burnt sienna, Venetian red, and my one positive colour—vermilion; three browns, raw umber, burnt umber, and Vandyke brown, and into each one of the tints shown in the arrangement there is some particle of every colour on my palette, so having the effect of various rays of light upon each other.

This theory you should formulate into a rule, to guide you in the selection of the various items of furniture and decorative carpets, curtains, wall papers, and covering materials.

So much for decoration or the colour of the house. I conceive it to be so important an item that I have enlarged upon it thus far. I should perhaps incise upon your minds as emphatically some of the more practical rules regarding the wholesome cleaning, painting, and papering of your houses; but in doing this I would not detract one iota of force from what I have already laid down. It might be said with truth that a beautiful arrangement of colour, calculated to give every satisfaction to the eye, and so pleasure to the mind, is as injurious to the constitution, if it be made of poisonous pigments not secured to the wall, but removable by friction or every draught of air, as if the colour were a bad one. Just as it is said from the point of view of the colourist that however wholesome the materials be, and however well fastened on to their

various surfaces, so that they have no injurious effect upon the physical frame, they still, being of unsuitable and inharmonious colour, have a prejudicial effect upon the health, acting through the eye and mind. It is necessary, therefore, to understand and give practical effect to both requirements. We will suppose, for an example, that you have taken a house previously inhabited. There is no accurate knowledge of the previous tenants. The condition of the paint and papers may give us an idea whether they were cleanly or otherwise, but no amount of inspection will reveal to us the fact that the seed germs of disease are present or absent. Therefore, our plain duty is to remove everything that can be removed about which there is the chance of any infection clinging.

Thoroughly strip away all old papers and wash down the walls. See that the men you employ, if you have not time to do it yourself, scrape out all dirt from corners and cracks, and fill up with good, clean, and pure plaster of Paris. Then thoroughly wash down and scrape off all colouring matter from ceilings and cornice, taking care that no particles of dirt remain in recesses. And for the woodwork, let it be well cleansed and rubbed down, to remove all loose particles, and at the same time, for the appearance of your finished work, rub it to a good even surface. When all the cleaning down is done, let the refuse be carefully removed from the floors, and have them scoured down in the most thorough fashion.

If damp places should now reveal themselves in walls, showing dark and mouldy stains, do not be content to attack them from the inside; be sure that the evil is caused by some defective down spout, or bad foundation, and insist on your landlord attending to it at once. So soon as the cause is stopped, then commence to dry the spot with good fires, and open the door and windows day and night; keep a current of good fresh air constantly circulating through the house.

If you are in haste to put on your papers, you may forward the drying of the damp places by building a small *coke* fire in a brazier, and keeping it close to the infected part. When the spot feels nice and dry to the hand, but there still remains some doubt in the mind as to all the moisture having come out, and you are compelled by want of time to proceed with the work at once, or if the dampness arise from some admixture of salt in the sand used in the plastering (a very frequent cause), then give the place a coat

or two of some of the damp resisting paints now made, and proceed with the papering.

In selecting the papers, you must above all things assure yourself that they are free from arsenic or other poisonous substances; that the colours are not loaded on so that they are readily removed by friction; or if you elect rather to paint your walls, or even simply to distemper them, see that the colours are well mixed with a proper amount of glue size, new and sweet. Be particular to have the paint well mixed, that it may be applied in thin coats, and not loaded in such a manner that the slightest friction will remove it. This injunction applies also to cornice and ceiling.

The woodwork must of necessity be painted in oil colours, if it has not from the first been simply stained and varnished. I could wish very much that this practice were more common, if it were done with care and thought. Even amongst the commonest deals that are used in the construction of ordinary houses there is much room for choice. The door panels being picked from the most nicely pencilled and marked grain, will, when carefully stained to a good rich brown, reveal a delicate pattern more beautiful than any stencil design you will be able to apply. I would avoid studiously those ugly yellows and imitations of mahogany one so often sees, and cling to good harmonious self colours, trusting to the natural grains of the wood for relief.

Good hard oak varnish on this stain, carefully and thinly applied in two or three coats, allowing ample time for setting between each, is, while more costly in point of labour, very little more so in material than if it be loaded on in thick treacly masses, and, for service, infinitely more lasting.

But if you must have the woodwork painted because it has been so before, put on the colours with the same care I advise for the varnishing. Two coats of properly mixed colour are better than six of badly-incorporated oil, turpentine, dryers, and half-pulverised powder. When the paint is ready, or you think it is, for applying, test it by placing a little on the thumb nail, and if you perceive, when rubbing the other nail over it, a gritty sensation, be sure the paint is not fit to use, and reject it. I do not say this simply because it will make you a bad and unpleasant surface, like sand-paper, when dry, but for this important reason, that all those bits of grit are so many particles of matter injurious to health, and in some cases actually poisonous. They are easily removed by friction, and so are liable to fly and lie about, to get on to the

lungs or into the pores of the skin. The paint, if properly mixed, should form a surface like the lacquer the Japanese cover their goods with.

It is hardly within the province of my present lecture to say more than I have already done about the colours and method of decoration, but just a few injunctions before leaving the subject.

Bear carefully in mind what I have said about choice of colour. By preference, cover your ceilings with a slightly patterned paper with a machine-glazed surface; it looks clean longer and keeps clean longer, the smooth surface rejecting particles of soot or dust.

Select a very quiet, small, geometrical pattern, and let the tint of it be in two shades of vellum. It is of course an excellent thing to paint the ceiling with four or five coats of paint in oil colour, as then it can be regularly washed; but this is an expensive piece of work. Paint the cornices, as I have shown you, in oil or distemper, and if you can manage it, and intend to remain in your house for eight or nine years, give your walls three or four good coats of oil paint, and stencil them all over in some neat, good pattern. This will provide you with many an evening's pleasant work when you have settled down, and when well done will be a lasting joy to you. Of course, if you must paper—for I do not much advise distemping the walls, being all one plain surface it shows at once every spot and mark and it is not worth the labour of stencilling—there are now-a-days ample sources from which to select cheap papers good in design and colour. Remember always to keep a harmony of colour and design. The question of the design viewed from the aspect of the *Æsthete*, that is, he who treats of the beautiful in Nature and Art, I am sorry I cannot now enter into, not because I do not consider that health depends upon this as much as upon colour, but that it is too large a subject for my time. Colour is perhaps the first thing for you to grasp when thinking of the decoration of your houses; design must naturally follow on this, not precede it.

Now it is just possible some one may be inclined to laugh at all I have said, and attempt to point out that although there may be some sense in it, it is an absurd thing to press the desirability of such precautions being taken by working men, for I suppose by the title of this series of lectures that I have the pleasure of addressing such. I can understand as well as any that in the present condition of things, and the relation of landlord and

tenant, there may be considerable difficulties to be overcome that may appear at first sight absolutely insurmountable.

A man, by the force of circumstances, has to take a house from week to week, he is never certain that he will remain in the same from one month's end to another, and very naturally he does not care to make any outlay of money that he can avoid ; for even if there were a law for compensation of such unexhausted improvements it would hardly meet his case ; as, if the principle I have laid down were commonly accepted, all such improvements, or nearly all, would be exhausted at the expiration of tenancy.

I am glad to notice that Mr. Crawford Munro, in the last of these series of lectures, is going to treat from its legal aspect the Obligations of Landlords and Tenants, and I trust that he may throw some light on the question. If he could prove to us that such cleansing as I have spoken of were an obligation placed on the two contracting parties, each to have his fair share, I should much rejoice.

But all the difficulties and impossibilities you can arraign against me do not in the least affect the necessities of the case. If you would be healthy in your houses, and would have your children healthy, you must take these precautions.

We will suppose for an instant that you are in a comfortable position, and as sure as one can be of anything here below of good and regular work ; you are naturally anxious to possess a place of your own, or to get one on a decent lease. Having done this, your duty is plain. Have you a greater respect for the doctor and the fever hospital than for your fellow artizans ? To which do you prefer to pay the money ? For it must be to one or the other. And which, I would ask you, is the better investment ?

In the one case, you pay and have in exchange anxiety, pain, and very possibly the loss of some of your little ones to deplore, and no stock-in-trade left. In the other, you pay and for your money you have a bright, cheerful home, all freedom from anxiety of sickness from that cause at any rate, and a stock of paint and paper that will last you with ordinary care for four or five years. Just once a year, at cleaning time, you must spend a few shillings to scrape down and colour-wash your ceilings, and any parts of the work that are at all calculated to retain anything noxious.

Would any man among you put on his back a shirt taken from a smallpox patient ? You would not, unless obliged, touch it with a pair of tongs. Then why, in the name of common sense, take

your wife and your little ones and go yourself to live in a house that has been the home of that and a dozen other nasty disorders, the deadly molecules of which are lurking in every crack and crevice of paper, paint, and woodwork, and only require a little dusting and disturbance to set them at liberty to float in the air, and be taken into the lungs and poison the system.

I do not forget that there are certain sanitary laws which compel the fumigation, etc., of infected houses when patients have been removed, but can you be sure they are effectual or that they have been carried out?

And now respecting the furniture and other items necessary to make the house a home.

For general principles : Do not overcrowd ; do not have large bulky things that are hard to move, that are too high to reach to the top of and dust, that take up too many cubic feet and inches of the precious air which in small rooms is a matter of great consideration.

In the bedrooms, which we will first consider, use iron bedsteads in preference to wood, and wire spring mattresses, rather than straw palliasses and feather beds. It is quite sufficient to lay over the woven wire mattress a good, well-opened flock or hair bed, the restful comfort of these is far greater than any other, while being springy and pleasant to the tired frame ; they permit, and almost insist on, a straight position being maintained. They permit also of so much more valuable air space under the bed, and being one-quarter of an inch thick, as against four inches or five inches of the palliasse, they allow the careful housewife to easily remove dust from the floor without the necessity of dragging the bed about the room. Do not allow the storing of bandboxes, boots, or any other articles under the bed, but leave the space free for a good circulation of air.

It is a good plan to stain the floor, all under, stopping up all nicks and crevices, and varnishing it, and let it be done rather dark, so that you can readily detect dust and fluff.

Let your pillows, while not being stones, be firm and full, that the head does not nestle too far from the fresh air. Dr. Moffatt, the great African missionary, who lived to such a healthy old age, scorned anything softer to lie upon than a straw mattress, and preferred a log of wood even to a hard horse-hair sofa pillow for his head.

Let the bedclothes be warm but as light as you can get them.

Do not add to the day's toil a night of hard labour with a heavy cotton quilt, or one of those heavy old-fashioned bed rugs. The clothes should be just eight inches or ten inches on each side of the bed wider than it is, but not more.

For the remainder of the furniture, if you will follow the rules I have already suggested as to its size, and the wood it should be made from, I do not think there is anything further to suggest from the healthy point of view.

About the curtains and carpets there is a good deal of difference of opinion. Their presence in a room adds so infinitely to its comfort and pleasant appearance, that one would be tempted to use them on the ground that what produces pleasure is as good for the body as the mind.

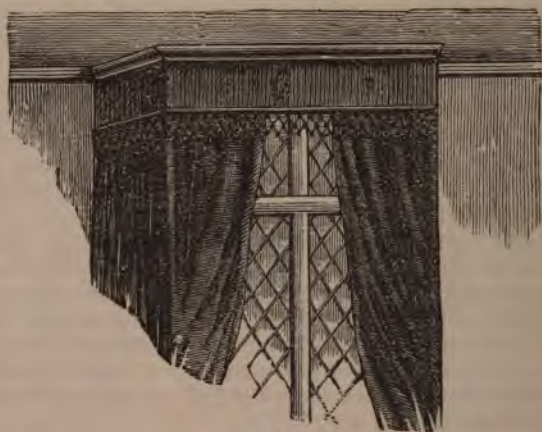


Fig. 3.

Naturally, in a room that is used for a fever hospital, one would at once remove *anything* in the least calculated to retain infection, but there is no necessity that one should always be compelled to view one's house from this point, and with ordinary care and careful housewifeliness such luxuries can be used with impunity.

Do not, of course, admit thick, clumsy materials in heavy folds that are difficult to push away from the windows and exclude light and air, or that hang on to the floor, and allow in their folds the secretion of dust and dirt.

You know the old-fashioned manner of draping windows; it

had its uses long ago, before they knew how to hang windows, when it was necessary to provide an effectual screen from the draughts that would force their way through; they then hung over the upper part of the window from a closely fitted wooden cornice, a valance, behind which the curtain ran on a pole, but this valance was a tightly fitted kind of apron and had its purpose to serve; not so the ridiculous substitute men put up now-a-days merely to imitate what had a meaning.

In Fig. 3 I show you the original thing that our great-great-grandfathers used, and you see plainly that it served its purpose; and in Fig. 4 I give you a notion of the modern base imitation, it has **no** meaning or reason for its being. If it were meant to



Fig. 4.

stop draughts it would maintain an unbroken line of defence, and not be cut and vandyked in this absurd manner.

I might talk for a week about the bad taste of such extravagances, but I wish merely to point out a much cleaner and healthier way of decorating the window.

In even many of our poorly built houses the draught that will come through badly-fitted sashes is not more than is good for the ventilation of the rooms. The large sheets of good glass we use now are capable of resisting the weather. It was not so formerly. When valances were instituted, the rough hewn frames built into the rougher stone work, frequently without plaster to stop crevices, admitted air at every point, and the casements were fitted with

bits of horn in leaded rims, instead of sheets of glass firmly embedded in putty. So then they needed the guarding apron above and heavy folding curtains below, but it is not so with us to-day. It would be as sensible to pierce our ceilings with holes for the smoke to pass out, when already we have the chimney, because our forefathers did so in their rude huts.

Let us therefore drape our windows with only so much material as will make them pretty and give a comfortable appearance when drawn at night, and for this it is not necessary that two or three feet should drabble on the floor.

Provide a simple wooden or iron pole from one-and-a-half to two-and-a-half inches thick, and about twelve inches longer than



Fig. 5.

the full width of the window, so that the curtain can be drawn clear away and not prevent any light from the room.

And if you can boast of a window wide and low as this (Fig 5), then let your curtains—made from one of the beautiful cotton fabrics that are in the market at very low cost now—reach just an inch or so below the sill. Let them be fastened with easy fitting hooks to the rings, in order that each week, when the room receives its cleaning down, they can be readily taken off and brushed and shaken out of doors. If you have a strong predilection for curtains to your beds, you can have them with impunity, only on the same terms. I dare not advise them; I should shock all my health-loving friends.

Many people tell us that on no account must we entirely cover floors with carpet. A margin must be stained two or three feet all round the room, and the carpet laid in a square in the centre, the margin being varnished. The idea, of course, is that the carpet not being held down by heavy pieces of furniture, usually placed against the wall, can be more easily taken up and shaken, and the smooth varnished floor all round is so much more easily dusted or wiped over with a wet cloth ; and all this is indisputable.

But, if these precautions are not taken (and my experience tells me that in the majority of cases they are not), this manner of covering the floor is no whit more wholesome than the all-over carpet. The times and seasons for the taking up of carpets and the scouring of floors are indelibly fixed in the minds of mortals, and new-fangled notions, if we can call them so, cannot overcome such prejudice.

I am almost prepared to maintain that with the varnished margin there is the greater risk, unless it be cleaned oftener than the carpet. We are told that the germs of disease, flying in infinitely small particles in the dust, are taken on to the lungs, and so fulfil their mission in us. You have noticed how quickly a cloud of dust is set in motion from a smooth surface, whereas a rough porous material, as a carpet, will hold the particles. These particles of dust and germs of disease ought not to remain in the carpet, but if they must be somewhere they are better there than on your lungs. If I were taking a man smitten with smallpox into a room carpeted and curtained, my first action would be to remove both, and principally because I should know that if they remained in the room during the fever they would have to be destroyed afterwards. Removing these things would not remove the cause of dust. I should still take every precaution to prevent its accumulation. Every day, or perhaps twice a day, I should have the floor wiped over with damp cloths, using a disinfectant to destroy all germs. But I am dealing now with our ordinary daily life, and am conscious that, freed from the painful reminder of the presence of disease in our houses, men and women are liable to forget all about necessary precautions.

Rather than say to you, "Cover your floors all over with carpet," I would say, "Whether you cover them all over or lay your carpets in squares in the centre of the floors, you must use the same precautions and prevent the accumulation of dust." Do not be persuaded into thinking that because you have centre squares and

nicely-stained and varnished margins you need trouble no further. Without doubt, if you are determined to banish dust from your floors, you can do so more easily when they are treated in this way than if covered all over.

If you have a friend you fear is not very cleanly, do not advise them this as a cure, for alone it cannot be so.

These remarks concerning carpets and curtains will, of course, apply throughout your houses. But I do not know what more to say than I have done concerning the other articles of furniture, unless you will permit me to use again the argument I used when speaking of colour, that those combinations which are subtle and true in their harmonies have a more healthy effect upon the mind than the heavy unsuitable ones. So, I can conceive, the beautiful form that brings the imagination into play, and gives room for thought, must affect the physical health through the mental. Certainly couches and chairs that are comfortable and restful, so being really artistic by rightly fulfilling their destiny, are more conducive to good health than others designed without this consideration. The irritable temper is less often roused if its surroundings, the articles of daily use, are convenient to their varied purposes. Designers should think more of this and be less haunted with the desire to produce something novel, and remember that "Construction should be decorated, decoration should never be purposely constructed," and also "That which is beautiful is true; that which is true must be beautiful." And then our shop windows and houses will cease the display of tawdry, comfortless, and useless rubbish with which they are filled to-day.

# HEATING, LIGHTING, AND VENTILATION.

By JOHN NEWTON, Esq., M. INST. C. E.

WHEN I undertook, a few weeks ago, to prepare a paper with the above heading, I was not aware that the subject had already been so ably dealt with by others, and my feeling on discovering this was to be relieved, if possible, of the obligation to read it. But on looking over the lecture delivered by Mr. John Angell, F.C.S., in the Session 1882-3, I came upon this remark—"The object of the Sanitary Association in presenting annually to the public these additional series of lectures is, however, so to extend Sanitary Knowledge, and so to impress it on the minds of their fellow citizens, by continual repetition, just as the continued dropping of water wears away the hardest stone, 'that it shall become so familiar and practicable as to become the daily guide of their lives.'" Entertaining as I do a high opinion of the Association, and a thorough appreciation of its work, I at once determined to follow in the footsteps of others, and to aid, as far as I am able, however imperfectly that may be, the objects they have in view.

Dr. Ransome commenced the first lecture of the present series by saying that it is intended to make "the dwelling-house the centre around which all our discourses are to play." He and others have already discoursed upon its "Site and Soil," its "Drainage," the requisite "Plans and Sections," its "Foundations and Materials," and "Plumbing," &c., and it has fallen to my lot now to discuss the Heating, Lighting, and Ventilation of the structure.

Whether we live in a cottage or a mansion, efficiency in these matters is essential to our health and comfort, and important, moreover, on the ground of cost, direct and indirect. In the following remarks my endeavour will be to show how efficiency can be obtained in the most economical and simple manner. No new principle will be enunciated—in fact, it is sometimes said "there is nothing new under the sun," and that "what is new is not true, and what is true is not new"—and all that will be

attempted will be a description of the systems already before the public, or the application of well-known principles to practice.

We will first consider the heating of the house, but in doing this we must keep in view the method of lighting, because lighting, except when done by electricity, implies also heating; ventilation then follows, being intimately associated with, and in fact rendered necessary by, both heating and lighting.

The open fire-grate is the commonest and most favourite mode of heating adopted in our English homes; but we have also the close stove, the gas stove, hot water pipes, and hot air.

The common grate warms mainly by radiation—that is, by rays of heat emitted from the burning fuel which strike objects which impede their progress, and these objects, according to their nature, absorb more or less of heat, which is afterwards communicated to the surrounding atmosphere. The close stoves and hot water pipes, on the contrary, heat principally by convection—that is, they warm the air which touches them, and this, by its levity and tendency to diffusion, spreads itself through the apartment. In the first, we have warm walls and furniture, with a cool atmosphere, and in the second, cold walls and warm air. A little of both is desirable, but radiant heat is undoubtedly preferable to heat by convection.

The sources of heat are primarily the sun and the earth itself, but secondarily, mechanical motion and chemical affinity. The latter is the source we have to deal with in heating our dwellings, and is described by chemists as “the chemical and atomic union of the combustible with atmospheric oxygen,” to effect which we must have the required quantity of air and “the proper mode of bringing it into contact and action with the combustible.” Without oxygen nothing will burn. A common mode of illustrating this is to place a lighted taper under a bell glass, and it will be found in a few moments that the flame sickens and dies out altogether. We have then the combustible only left, the oxygen having amalgamated with the carbon of the combustible and formed carbonic acid gas.

The amount of heat evolved in the process of combustion depends to a great extent upon the quantity of oxygen combining with the combustible. Thus, a lighted taper, or a piece of iron wire even, heated to redness, and plunged into pure oxygen burns intensely as long as the oxygen lasts, far more so than in the case of a taper burning in ordinary atmospheric air, only about twenty per cent of which is oxygen.

It will thus be seen that to generate heat we must have oxygen atomically mixed with the carbon contained in the coal or other combustible employed, and as air, when heated, becomes expanded, it is manifest that a current of cold air will supply a greater quantity of oxygen than a similar current if heated and consequently expanded.

Fires usually burn more brightly in winter than in summer, and the sun's rays will sometimes even extinguish a fire.

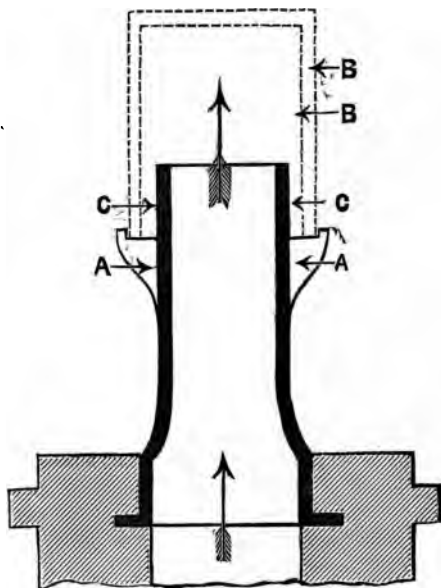
An important point to be considered is the flue for carrying off the products of combustion. It is scarcely necessary to observe that these gases are injurious to health. Taking the bell glass illustration again, it will be found that although the air in the glass was perfectly pure at first, it soon became changed in character. The flame expires, it is unfit for respiration, and consequently animal life could not exist therein. The change is two-fold—we take away a vital element and substitute a poison.

The action of the flue or chimney is very simple. Gases and vapours expand in proportion to their increments of heat, the expansion being equal to  $\frac{1}{480}$ th part of the volume at zero for each degree of heat added. Thus, if 460 measures of air at 0° be raised to 40°, the space occupied will be enlarged to 500, and if raised to 60° it will be increased to 520. Suppose the average temperature inside a flue to be 60° and outside 40°, the height of the chimney being 26 feet, then as 520 : 26 :: 500 : 25 feet—that is, a column of air 25 feet outside will equal in weight 26 feet inside; in other words, we have a column of air, or pressure, of one foot outside creating an upward current of the heated gases inside the chimney.

It is easy to ascertain the velocity of the ascending current from a well-known formula applicable likewise to falling bodies, namely,  $\sqrt{h} \times 8$ , which in this case becomes 8 feet per second, or 480 feet per minute; it is usual in practice to make an allowance of at least 25 per cent for friction, irregularities in the flues, &c., but it is not at all uncommon to have an *actual* velocity of 10 to 12 feet per second, which, with a flue 14-inches  $\times$  9-inches, means 30,000 to 40,000 cubic feet per hour abstracted from the apartment.

Chimneys sometimes overpower each other—that is, a flue from one fire place will be fed from a down draught in some other. In some cases this arises from unequal height of chimney shafts; in others it is caused by a larger fire in one room than another, and sometimes it is due to the proximity of higher buildings, over

which the winds sweep, and fall as it were upon the top of the lower chimney and down it into the rooms of the house. The first essential is to provide each with a sufficient and independent supply of air, so as to render it unnecessary for one ever to rob another, and if the stack is too low, and cannot be sufficiently raised, we must apply a suitable cowl, many good designs for which are before the public, such as Boyle's, Banner's, Ellison's, and others. Mr. J. Brierley, C.E., has lately patented a chimney terminal which promises to be efficient, more especially in cases of down draughts, consisting of a wire-work cap, reminding us somewhat of the Davy lamp. Its simplicity and economy are also greatly in its favour.



**A A**—Are three or four small brackets to support wire-work caps. **B B**—Are the double wire-work caps, space between them 1 inch. **C C**—Annular space between flue and wire-work caps, about 1 inch.

We have now arrived at this point, that there must be a sufficiency of air to effect combustion, and sufficient means of exit for the products of that combustion.

The ordinary open fire-places meet these conditions, but not always in the most economical way. The most common defects consist in not sufficiently utilizing the heat generated, especially at the back and sides of the grate, and in abstracting oxygen unnecessarily from the apartment to be heated. It is often said that an open fire-place ventilates the room, and this is partially true, but it does not effectually carry off the heated and impure gases arising from respiration and gas lights, as these are formed above, and rise to higher levels than, the chimney opening. Its action is chiefly by radiation, the degree of heat at any point being inversely as the square of the distance from the fire; but as the rays of heat thus sent out indirectly warm the air in front, much of the air so warmed is drawn up the chimney, its place being supplied by air from the nearest door or opening, thereby causing unpleasant draughts, and, in the words of Count Rumford, "whilst the draughts chill one part of the body, the rest is roasted by the fire in the fire-place, and this cannot but be injurious to health."

In the report of the Smoke Abatement Commissioners, 1882, the jurors of the Exhibition at South Kensington say:—"We have considered that one of the chief essentials of a grate, or a stove, should be that no noxious fumes should be given off into the apartment, and . . . that there should be abundance of radiant heat; subject to these considerations, we believe that apparatus to be most worthy of recognition in which the ratio of heating power to the amount of smoke produced is the greatest." The occupant of our dwelling-house, however, will go a step further, and say that he desires a bright and cheerful fire, with a maximum of heat from a minimum of coal.

The exhibits were classified as follows:—

- I. Open grates having ordinary bottom grids and upward draught.
- II. Open grates having solid floors, adapted for slow combustion and upward draught.
- III. Open grates underfed, supplied with fresh fuel below and upward draught.
- IV. Open grates supplied with fresh fuel at back, sides, or from hoppers and upward draught.
- V. Open grates having a downward, backward, or lateral draught.
- VI. Close stoves.

All the grates and stoves were subjected by Mr. D. K. Clark, M. Inst. C. E., to most carefully conducted experiments, with a view to ascertaining their heating powers and smoke-producing propensities.

It is not easy to condense sufficiently the results of these tests so as to bring them within the compass of an evening lecture, but the following are some of the principal :—

#### DISTRIBUTION OF THE HEAT GENERATED.

	Open Grates. Per Cent.	Close Stoves. Per Cent.
Utilised in the Room.....	42	54
Carried up the Chimney .....	43	24
Lost by imperfect combustion and con- duction externally .....	15	22
	100	100

A much larger proportion of heat is thus shown to be utilized than popular notions indicate. In a lecture recently delivered in London, and reported in the periodicals, it was stated that not more than 10 per cent of the heat generated was actually made available.

The effect of air-heating arrangements when combined with ordinary grates is important, and may be thus summarised :—

	No. of Tests.	Rise of Temperature per Pound of Coal per hour.	Radiation ditto.
Class 1—Ordinary Grate.....	10	2'45	4'21
Air Heating ...	9	3'37	2'88
Class 2—Ordinary Grate.....	10	3'02	4'09
Air Heating .....	2	2'81	3'93
Class 3—Ordinary Grate.....	5	3'81	3'61
Air Heating .....	...	...	...
Class 4—Ordinary Grate.....	4	3'37	3'50
Air Heating .....	2	2'41	2'42
Class 5—Ordinary Grate.....	7	3'28	3'22
Air Heating .....	11	3'45	4'00
Class 6—Close Stove .....	8	4'23	1'64
Air Heating .....	2	3'79	1'78
Totals—Ordinary Grates and Stoves.....	44	3'36	3'38
„ Air Heating.....	26	3'17	3'00

The results indicate that the common form of grate can be rendered more efficient by combining air-heating arrangements with it, but that in the slow combustion and underfed grates no advantage is thereby gained. In regard to close stoves, such appliances appear to be positively destructive of efficiency.

The temperature at different levels in the test room was also ascertained, and the results showed that at six feet above the floor the air was warmer by about  $5^{\circ}$  than it was at six inches; at 14 feet it was  $3^{\circ}$  to  $4^{\circ}$  warmer than at six feet, and these inequalities were practically the same with air-heating grates as with ordinary ones.

Let us now examine a little more closely the best of the exhibits, in doing which we will exclude close stoves, as being unsuited to an ordinary living-room, and also such as are designed for burning anthracite coal only. The air-heating grates are indicated by the letters A.H.

Exhibitor.	Rise of Temperature.	Radiation.	Smoke Shade	Awards.
Class 1—W. P. Taylor.....	3'12	4'00	2'62	Hon. Mention. Hon. Mention.
Radiator Range Co.....	2'87	4'98	...	
Rosser & Russel...A.H.	3'85	5'71	1'92	
G. Haller & Co...A.H.	3'73	2'41	3'00	
A. B. Verrier .....A.H.	4'69	2'00	3'66	
E. H. Shorland ...A.H.	2'16	1'77	2'87	Hon. Mention.
Class 2—Doulton & Co.....	3'78	2'59	1'33	
J. B. Petter .....A.H.	4'12	3'38	2'81	
Steel & Garland...A.H.	3'25	5'22	3'86	Gold Medal. Silver Medal. Bronze Medal.
Class 3—Brown & Green.....	2'85	3'72	2'12	
E. H. Shorland .....A.H.	4'71	4'68	3'00	
E. R. Hollands.....	4'90	3'62	2'52	
W. S. Melville .....A.H.	4'93	3'50	4'14	Bronze Medal. Bronze Medal.
Class 4—H. E. Hoole .....A.H.	6'33	5'06	2'55	
J. M. Stanley .....A.H.	2'66	1'81	2'24	Silver Medal. Bronze Medal.
Class 5—Clark, Bunnett & Co.	2'04	3'40	3'31	
T. E. Parker .....A.H.	5'43	2'79	2'20	Bronze Medal. Bronze Medal. Bronze Medal.
Deane & Co.....	4'00	5'09	3'90	
W. J. Henry .....A.H.	3'92	5'06	1'65	
M. Feetham & Co.A.H.	2'63	3'71	1'19	
Steel & Garland...A.H.	4'58	3'60	3'66	

Whilst fully admitting the great importance of preventing smoke, we must also aim at obtaining the heat we require from the least expenditure of coal, but the jurors evidently viewed the smoke part of the subject as the paramount one. Mr. Clark's experiments show, first, the rise of temperature in a room by the consumption of 11b. of Wallsend coal per hour; secondly, the degrees of radiant heat; and thirdly, the smoke shade. The report, after alluding to three grates in Class 3, says:—"Brown and Green's grate was not so efficient as the grates just named, but it made the lowest smoke shade in its class;" and yet this grate, with its ugly and objectionable hopper in front, obtained the gold medal. Still more remarkable appears the decision in reference to Hoole's Radiating and Reflecting Grate in Class 4, which gave the highest results in heating, with a very moderate smoke shade, and yet the award was a bronze medal only. In Class 5, the report says that Parker's grate "stands at the head for efficiency," and Ingram's grate by Clark, Bunnett, and Co., was but moderately efficient, yet Ingram's obtained a silver medal and Parker's a bronze one. Other apparent inconsistencies exist in the decisions referred to, and although we may willingly admit the great value of the experiments themselves, it will be better to draw our own conclusions from them rather than allow the awards to influence us.

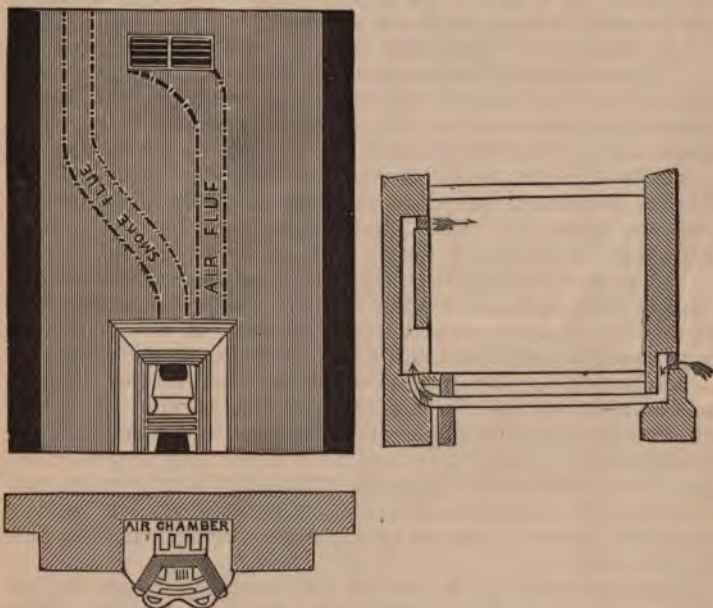
In heating power, the slow combustion grate appears to give better results than the ordinary grate with its bottom grid and upward draught, but there is a brightness and cheerfulness in the blaze of the latter which is absent from the former, and many of us will doubtless prefer spending a little more in coal so as to obtain the brighter fire.

But two improvements are required in most of them; (*a*) to supply the necessary oxygen from a source outside the room, and (*b*) to utilize the back heat. Whether the house be detached or one of a row, the first can easily be accomplished by means of an opening in the hearth communicating with a pipe fixed in the external wall, or laid under the floor to some other outside source, its inlet being protected by an iron grating, and its outlet beneath the grate fitted with a damper to regulate the incoming current. The utilization of the back heat should always be provided for in designing new houses, and even in existing houses the saving in coal would soon repay the cost of its installation.

It is somewhat singular that although the first of these was advocated as far back as 1658, by Sir John Winter, and the other

in 1713, by Cardinal Polignac, they have not as yet come into general use.

Many of the exhibits at South Kensington, however, embodied the ideas in some shape or other, and the Committee say in reference to one of these:—"We would call particular attention to the pattern of a grate devised by Captain Douglas Galton, C.B., about twenty-two years ago, for use in barrack rooms, and adopted for that purpose by the War Office. On account of the position



occupied by Captain Galton\* with regard to the movement, this grate was not shown in competition, and was therefore not tested in the testing-house, which is unfortunate, as it might at least have served as a standard of comparison, and we believe it to be certainly one of the most effective of the grates in the Exhibition." Captain Galton remarks of this grate—"Fresh air is admitted to a chamber formed at the back of the grate, where it is moderately

\* Captain Galton was one of the Executive Committee.

warmed by a large heating surface, and then conveyed by a flue, adjacent to the chimney flue, to the upper part of the room, where it flows into the currents which already exist in the room. The effectual combustion of the coal is obtained by limiting to a certain extent the draught at the bottom of the grate and supplying warmed air on to the top of the fuel at the back of the fire. The ventilating fire-place thus retains the advantage of giving out radiant heat, and it provides ventilation without draughts by admitting air, moderately warmed, into the room at a convenient point to replace the air which is removed by the chimney."

Mr. Shorland's "Manchester Grate" is similar in many respects to Captain Galton's, and superior in some of its details. The warmed air in these grates may either be conveyed to the adjoining room or bedrooms over, or it may be discharged into the same room at any level between the chimney-piece and the ceiling.

Mr. Shorland appears to have made these ventilating and air-heating grates a speciality, the great number of them fixed by him, and the satisfaction which they appear to give are strongly corroborative of their excellence.

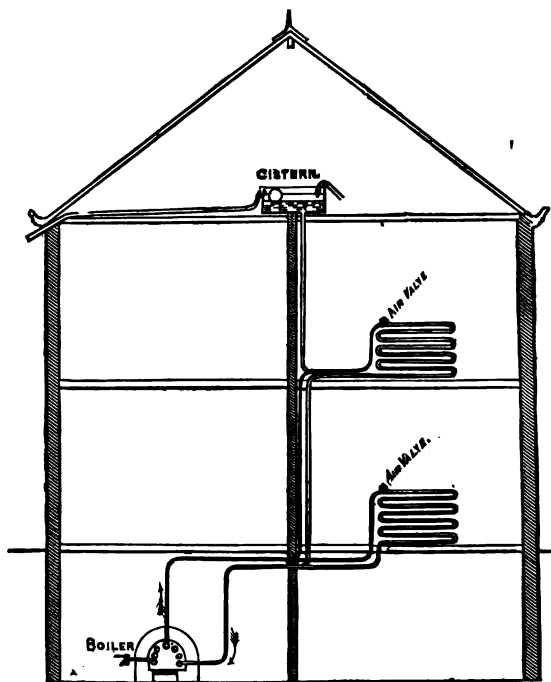
A very simple and cheap contrivance in the form of movable vertical bars has lately been introduced, called a coal saver. The cost of this is only 1/-, and it can be fixed to any grate. Its appearance is ornamental rather than otherwise, and it saves coal.

Another mode of utilizing the otherwise wasted heat is by means of a boiler at the back of the grate, connected with which is a circulating pipe and a coil of pipes in some convenient situation for heating the house. The close boiler at the back of the kitchen grate is ordinarily used for heating water for culinary purposes and also the bath, in which case a copper cylinder or an iron or slate cistern in the roof is used as an expansion chamber and store for the hot water.

In moderately large houses we may justifiably adopt the hot water circulating system in addition to the open fire-grate. The boiler should in this case be placed in the cellar or rear of the house, and a coil behind an ornamental screen fixed in the entrance hall, and if the rooms are large, the pipes may be extended to them and even to the bedrooms and landings above.

The size of the pipes may be two, three, or even four inches in diameter, according to the work they have to do, and it is better to have a comparatively large heating surface, with a moderate heat, than a small superficies with a high temperature. The

diagram shows a common arrangement of the pipes and coils, &c. The dark shades indicate the flow pipes rising from the top of the boiler, with a small branch to the cistern; the lighter shades show the return pipes, terminating in the bottom of the boiler. Air valves should be fixed wherever it is possible for air to accumulate; but as these require attention, small air pipes extended



upwards to at least the level of the cistern would be better, and they would of course be self-acting.

The behaviour of water in the pipes is identically the same as that of air in a chimney flue. Heat expands both, and as the heated water rises to the top of the boiler and then up the ascending pipe, so the colder and heavier water in the descending tube falls to, and enters at, the bottom of the boiler, thus causing a

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circulation, the velocity of which is governed by the difference in temperature between the ascending and descending columns.

A high-pressure system of circulation, known as Perkins' system, was formerly in favour, especially in the warming of churches and public buildings, but the liability to accident from bursting of the pipes and the escape of water in such cases at an excessively high temperature operated against it.

Many years ago a panic occurred in one of our Manchester churches on the occasion of a burst during the sermon, the sound of which resembled a gun discharge, the escape of hot water and steam being most alarming.

Steam may be advantageously employed in heating works and large buildings, but in ordinary dwelling-houses its use is not desirable, neither would it, in such cases, be so economical as water.

Gas is sometimes used for heating purposes, and has its advantages where the requirements are intermittent, as in cooking operations; but for continuous work it is expensive; sometimes it is used alone, in which case the heat is transmitted by radiation or reflection; in other cases it is used with asbestos or coke, and occasionally in close stoves. Mr. Clark's experiments showed that to raise the temperature of a room 2° required 10 cubic feet of gas, whereas half a pound of coal would perform the same duty. The gas at 2/8 per 1,000 cubic feet would cost one-third of a penny, whereas the coal would only cost one-thirtieth of a penny.

Heating by hot-air arrangements is not generally in favour in England, more especially in dwelling-houses, and the great difficulty of preserving the purity of the air in its passage over and through the ducts prior to its delivery and diffusion renders this system generally unacceptable. In large establishments its adoption under proper precautions may be permissible, but not so in ordinary dwellings, where the open fire-place, and possibly hot water pipes, can be more judiciously employed.

**LIGHTING.**—We will now consider the lighting of the house. What is light? It is a ray emitted from a body made luminous by heat, and all bodies are rendered luminous when heated to incandescence. The beautiful incandescent lamp of electricity consists simply of a fibrous substance intensely heated by the passing of an electric current through it, and the brilliant arc light is made up of innumerable small particles of carbon heated in the same way to whiteness. Professor Tyndall says that "the light

and heat of our flames are due to the clashing together of the oxygen of the air and the constituents of our gas and candles," and Sir Robert Kane observes "in all cases where bright light is produced in combustion, one of the bodies engaged must be solid, and the light is really derived from its being ignited;" but a spark must be applied before either can be produced, and without this the elements may exist side by side for ages without actively associating.

Some of us may possibly remember the farthing candle, or even the rush light, being used, and the old-fashioned snuffers and tray may still be seen occasionally, but these are now almost things of the past. It may not be uninteresting to compare the cost of the light which our forefathers had from candles with the light which we obtain from gas. Let us take gas at  $2/8$  per 1,000 cubic feet, as now charged in Manchester, and its illuminating power at twenty candles—that is, the light from an Argand burner consuming five cubic feet per hour as being equal in intensity to the light produced by twenty sperm candles of six in the pound, each burning at the rate of 120 grains per hour.

The gas in this case will cost one-sixth of a penny per hour, and the sperm candles, at  $1/-$  per pound,  $3\frac{3}{4}d.$ , or more than twenty times the cost of gas. In other words, one candle will cost more than a gas jet giving twenty times as much light. Wax candles, being dearer, give a result still more in favour of gas, and the common tallow candles, which are about half the price of sperm, are nevertheless eight or ten times the cost of gas.

In the present day we use lamps supplied with petroleum and other oils, as well as gas, candles having been snuffed out. Electricity has made rapid strides, and will in all probability be an economical source of light at no distant date, but as yet its cost debars its general adoption. We have therefore only to consider the oil lamps and gas.

Comparing the cost of these we have—For gas burning five cubic feet at  $2/8$  per 1,000 cubic feet,  $2d.$  per twelve hours; twenty sperm candles, at  $1/-$  per lb.,  $3/9$  per twelve hours; colza oil, giving same light, at  $4/-$  per gallon,  $8d.$  per twelve hours; petroleum (daylight oil) at  $10d.$  per gallon,  $1\frac{7}{8}d.$  per twelve hours.

The petroleum oil is therefore the least expensive illuminant before the public, but its use involves considerable trouble and care, and the results here given are by the most improved lamps. The risks and breakages, moreover, are important considerations

both for the housewife and her husband, and not unfrequently the combustion is so imperfect that disagreeable smells and waste are caused.

It is barely a century since coal gas was first used as an illuminant, and the little town of Redruth, in Cornwall, may be said to have been its birthplace. Here in 1792, to the wonder and delight of his neighbours, William Murdock—all honour to his name—first made coal gas, and lighted up his house with it. Nay more, he actually carried it about with him on dark nights in a leathern bag, and used it in place of a lantern. But these were not days of railways and telegraphs, and little was heard of this new method of lighting for many years afterwards. In 1798, however, we find Messrs. Boulton and Watt experimenting upon it at Soho, and in 1803 the whole of their works were lighted with gas. Two years later the cotton mills of Messrs. Phillips and Lee, in Salford—at that time the largest in the kingdom—were successfully lighted under Mr. Murdock's personal supervision, an interesting account of which is published in the Transactions of the Royal Society for 1805. At the same time Mr. Clegg, on behalf of Messrs. Boulton and Watt, was engaged in erecting gas works at Sowerby Bridge, and during the next few years many other concerns were supplied with gas, amongst which may be mentioned the large works in Manchester belonging to Mr. Greenaway and the extensive cotton mills belonging to Messrs. Ashton at Hyde, also the Stonyhurst College. It may fairly be said, therefore, that although Cornwall was the birthplace of gas, Lancashire was its cradle.

It would be interesting to pursue the history and mode of gas making, but our object is more especially to consider its economical application to the lighting of our dwellings.

Very few of us have any choice in the article itself. We must take what the Corporation or company give us, but we can complain—that is an Englishman's privilege—if the quality is not to our satisfaction. It is, however, but seldom, and under very exceptional circumstances, that the gas managers supply impure gas, or gas of less illuminating power than they are under obligations to supply. Far more frequently the fault lies in our own fittings, which may be defective, or which may allow the gas to escape under such a pressure that perfect combustion cannot be effected. In either case it is important to apply a remedy with as little delay as possible. If the pipes or fittings leak, send for a

plumber, who will soon discover and remedy the defect. If the pressure at the burner is too great, check this by turning the tap at the meter, and if the number of lights varies considerably, it will be desirable to fix an automatic regulator, which will ensure an even pressure at the burner whatever it may be in the mains. There are many such regulators sold—good, bad, and indifferent—probably more of the latter than the former, but one of the good ones which may be named is Stott's, this having gained, amongst others, the prize medal at the recent Crystal Palace Exhibition, 1882-3.

A common objection to gas is that it makes a room unhealthy, and that it destroys our books and pictures. This is frequently so, but the same objection applies to any other illuminant yielding the same quantity of light, if proper ventilation is not provided. It is well known that people are ordinarily satisfied with less light from lamps or candles than they would be from gas. Let us suppose four wax candles in the drawing-room, and four fairly good gas burners in the library. The light from the four burners will be sixteen times that afforded by the four candles, and if we treat ourselves in the library to so much extra light we must be prepared to put up with the proportionate ill-effects necessarily resulting from its production.

Let me not for a moment be understood as saying that impure gas is not injurious to health, or even to book bindings and pictures. It is undoubtedly so, but the injury generally arises from excessive heat, caused by the large quantity of gas used and deficient ventilation.

As in heating, so in lighting, the inventions and patented improvements are innumerable, and as these are usually said to give more light with less gas than others, we may not unreasonably expect shortly to have light from burners so improved that they will require no gas at all.

The efficiency of gas lighting does, however, depend to a considerable extent upon the burner and other appliances used. The steatite and porcelain have taken the place of metal burners, and flat flames have superseded ratstail and round flames. A moderate-sized burner, moreover, will yield a better light than a number of smaller ones burning the same quantity of gas. For example, a burner consuming five cubic feet per hour will give more light than five similar burners, each consuming but one cubic foot, and an efficient pressure regulator will secure to the burner

its proper quantity of gas for ensuring under all conditions a good and steady light.

Globes and shades interfere materially with the radiation of light. It is thought by many that they render it softer and more equable, but this is questionable, and it is certain that they absorb and waste a large percentage of light, amounting in some cases to as much as 50 per cent.

About ten feet of atmospheric air is required to mix with one foot of gas to ensure perfect combustion. The quantity varies of course with the quality of the gas, hence the difficulty of constructing a lamp which shall be equally good under all circumstances. A deficient supply of oxygen means little heat, and a low degree of luminosity. A sufficient supply gives a maximum of both, and an excess produces the same amount of heat, but less light. The Bunsen burner illustrates the latter example. A large proportion of air is mixed with the gas previous to its ignition, and the result is a sickly blue flame, with a concentrated heat, equal to, but not greater than, the radiant heat given off by the pure white flame. In the one case it is concentrated, and in the other diffused by radiation in all directions, hence in cooking appliances the Bunsen burner is the most effective for boiling, and the white flame, from a proper burner, most desirable in an oven, as the products of combustion in this case are less offensive.

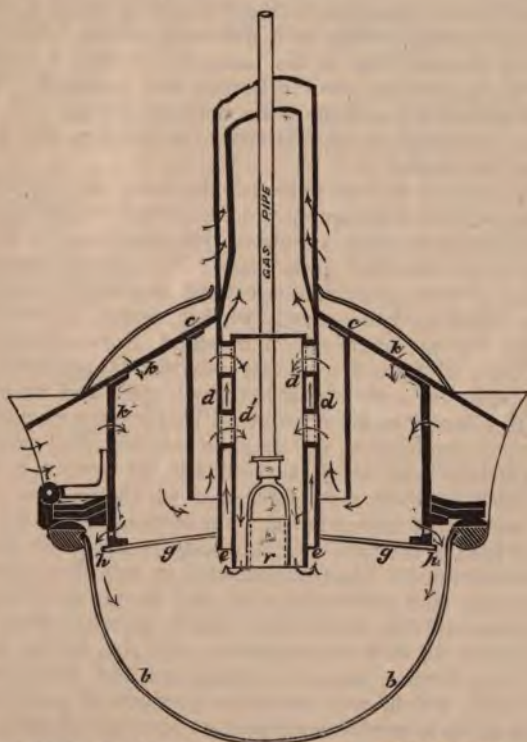
The introduction of the "Regenerative burner" marks a new era in gas lighting. Dr. F. Siemens, one of the earliest inventors, says:—"Under the Regenerative system the products of combustion are continuously returned by a downward current to the interior of the burner itself, and there utilized to heat fresh gas and air prior to use. The result is that combustion is absolutely perfect."

The Grimston, Clark, Wenham, and other so-called "Regenerative" lamps in many respects resemble Siemens', and the favour with which these have been received by the public tends to show that they possess advantages over the ordinary burners. The Siemens' Patent Gaslight Company say that by their system the consumption of each cubic foot of gas gives a light equal to at least 50 per cent more than the light afforded by the old burners, and some of the other inventors claim even more.

An erroneous opinion prevails in regard to the action of these lamps, and the cause of their increased efficiency. The statements of some of the patentees even have tended to foster the illusion, one declaring that the high results are obtained simply

by an ingenious application of the regenerative principle, whereby *the gas and air are raised to a high temperature by the heat of the flame underneath.* The fallacy lies in the idea that perfect combustion requires the aid of extraneous heat, as such is not the case,

CLARK'S VENTILATING LAMP.



B B—Semi-globular glass hinged. C C—Lamp top. D D', E E'—Concentric tubes.  
G G—Reflector. H H, K K—Air holes. R—Burner.

and the greater efficiency is undoubtedly due to the larger *quantity* of air which the heated chambers of the lamp cause to be mixed with the gas as it issues from the burner.

The judges of the International Gas Exhibition, 1882-3, stated that Grimston's burners gave a light equal to 4·83 candles, and

Clark's burner a light equal to 4·76 candles per cubic foot of gas, whilst the best Argands gave from 3·13 to 3·63 candles only. "The results," they remark in reference to Clark's, "obtained with this burner, in all the positions, are remarkably good, and we are disposed to consider it the best burner tested."

In most of these Regenerative lamps some difficulty is experienced in lighting them, as, until a draught is created, the flame will scarcely survive, owing to a deficiency of air. Mr. Schulke attempts to remedy this in his lamp by forming a combustion chamber immediately above the burner, and a special flue therefrom communicating with the main chimney above.

Another advantage of these lamps is the facilities they afford for ventilating the rooms.

**VENTILATION.**—We now approach the most difficult branch of our subject—difficult on account of the varied circumstances and conditions under which it is required, yet simple when viewed in reference to fundamental principles. We cannot overrate the importance of ventilation, neither can we thoroughly comprehend its urgency until we know exactly what it means. Literally this is "fanning," but as commonly understood, it means substituting fresh air for foul air. Nature has provided a perfectly healthy atmosphere, but man pollutes it both by himself and the agents he employs to minister to his comforts. This is more especially consequent upon combustion, and life itself may be called combustion. We have already seen that in an ordinary fire oxygen is required to mix with the carbon of the fuel, after which we have carbonic acid gas and earthy matter in the form of ash. So in the human frame, the food is the fuel, and the body is the grate where the carbon is consumed. Heat is generated in this slow combustion stove, carbonic acid gas is given off, and in place of smoke we have an imperceptible, but not less impure, gaseous vapour emitted by perspiration as well as respiration. So also in the case of a lamp or a gas burner, oxygen is abstracted and poisonous gases take its place, which, with the other products of combustion, so vitiate the air as to render ventilation an absolute necessity.

The human frame is, however, something more than a combustion stove, and may not inaptly be described as a regenerative furnace. Some writer has remarked that "the moment we begin to live that moment we begin to die," and to sustain life we must have a continuous re-vivifying of the materials composing the frame itself, but the process produces emanations and exhalations

which are offensive in themselves and injurious to the system if again inhaled, and we have therefore not only deleterious gases but effete and invisible solid particles of organic matter—the result of decay and decomposition—to get rid of.

It is generally admitted that foul air is fatal to health. "Doctors differ" is an old adage, but in this they do not differ, and to the medical profession above all others the public are indebted for a persistent advocacy of fresh air. The difficulty lies not so much in satisfying people that impure air is hurtful as in convincing them of its presence. They cannot see it, and in most cases cannot even smell it, consequently they will not believe in its existence, and hence their apathy.

We can no more exist without air than fish can live without water, and just as they are poisoned by polluted water, so are we by impure air. The evil is in proportion to the degree of impurity. A little produces listlessness; still more, headaches, and possibly fainting; and in extreme cases, suffocation, as in the oft-quoted case of the Black Hole at Calcutta.

Professor Hosking makes this very pertinent remark: "People who would revolt at the idea of drinking out of the same cup or glass with a stranger, or even with a guest, suffer no annoyance from, and feel no disgust at, inhaling what has already passed through the lungs of those who may be shut up in a room with them, however close the room may be."

Chemists tell us that pure air is composed of 21 parts of oxygen and 79 parts of nitrogen, and that any alteration of these proportions implies deterioration. If, therefore, we take away a certain proportion of oxygen, and more especially if we substitute some other compound, such as carbonic acid gas, we necessarily destroy its health preservative properties. In that state it is a foe to health, we cannot cope with it at close quarters, and we are forced either to escape from it or compel its escape from us.

Ventilation implies movement—a current of foul air passing out, and an equal current of fresh air coming in. We, therefore, require an outlet and an inlet, and these should, as far as possible, be independent of both doors and windows. Under ordinary circumstances we find the temperature near the ceiling many degrees higher than at the floor level. Respiration, radiation from the fire and the gas lights primarily warm the lower stratum of air, but as this becomes heated it rises, and colder air from the immediate locality takes its place in like manner to be heated and

replaced, thus causing a continuous upward current. We have, therefore, a force at our command—the action of a natural law creating a current of air—and all we have to do is to make an opening at or near the ceiling, so as to allow it uninterrupted egress, and such further provision as will permit the free ingress of fresh air to fill the void thus caused.

In the absence of any special ventilating shaft or pipe, these openings may be made into the smoke flue, just below the ceiling, and filled with an ornamental grating, behind which are noiseless talc flaps, hinged from the top of the frame, their extreme lightness causing them to close when there is the least tendency to down draught. Sometimes a special flue is carried up and covered with a cowl, but it is rarely that such an apparatus is applied to an existing dwelling. In the erection of new houses ventilation flues should always be constructed side by side with the smoke flues, and these may be formed of brickwork in the ordinary manner, or still better, with glazed socketed pipes.

It is an erroneous idea, but commonly entertained, that carbonic acid gas—one of the principal intruders we desire to eject—will sink to the lower stratum on account of its greater specific gravity, but this is not so, as, by the law of gaseous diffusion, the atoms or particles composing any gas will intimately commingle with any other with which they may be joined. This can be easily proved by introducing a minute quantity of sulphuretted hydrogen or perfume of an odorous body, almost immediately after which we can detect it by smell in every part of the room.

The position of the inlet is also important. If the fresh air has been warmed it may be admitted at the floor level, but if otherwise, this would be manifestly improper, as the effect would be to cool the part of the room which we more particularly wish to warm, and would be altogether opposed to the good old maxim which tells us to keep our heads cool and our feet warm.

In arranging for the admission of fresh *cold* air the following points should be carefully attended to:—

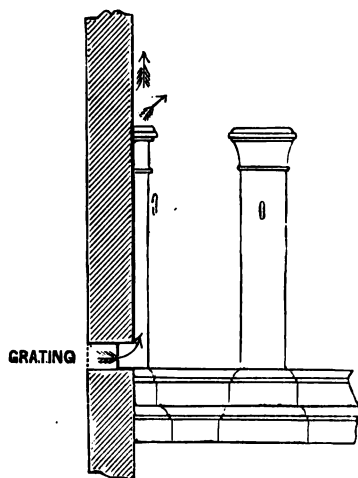
1. So place the inlet that the driest and purest air in the neighbourhood only can enter it. In no case should it be drawn from basements, cellars, or living rooms.

2. Protect the inlet by two layers of fine copper gauze, and between them fix a rough woollen cloth. These will filter the air and keep out the *blacks*.

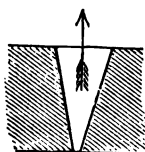
3. Let the air enter the room at a level of not less than six feet

above the floor, as far removed from the foul air outlet as possible, and directed upwards or sideways. Two inlets are, of course, better than one, and in large rooms three, or even more, may be necessary to ensure complete diffusion without draughts.

4. If the air be admitted through vertical pipes, sometimes designated "Tobin's Tubes," see that they are perfect throughout, and that both ends are protected by gauze or gratings. A regulating valve should be fixed inside, and facilities should exist for examination and cleaning out the tubes.



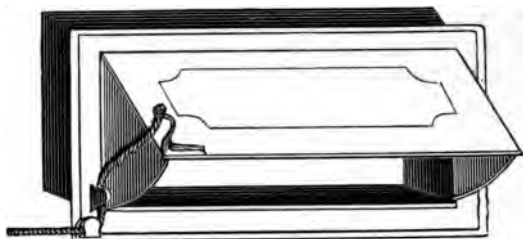
5. Where the inlets are simply orifices in the outside walls, their section should be conical, thus—



so as to check the incoming current of air and help its diffusion, but a more perfect appliance is the Quadrant inlet ventilator,

which, being balanced, will remain open or closed as may be desired.

Sherringham's ventilator is very similar, but has a cord and pulley to regulate the door.



If the fresh air is warmed before entering, as done by Galton's, Shorland's, and many other grates, or by hot water pipes, it may be admitted at any level, but the lower the better.

The Æolus Water Spray and Ventilating Company produce a current of air by means of a water spray, which at the same time washes it; either the air of the room or that obtained outside may be so dealt with, but the system is not economically applicable to dwelling-houses.

A common cause of failure in ventilation is insufficiency in size of apparatus. In an ordinary-sized room the quantity of fresh air required to keep it in a tolerably healthy condition should not be less than 500 cubic feet per hour for each individual, and about the same for each gas burner. With four people and four gas lights, this would represent 4,000 cubic feet per hour, and as it is not desirable to admit the air at a greater velocity than two feet per second, the size of opening required to admit this quantity would be nearly half a square foot—say 12 inches  $\times$  6 inches. We should in all cases, however, make these openings somewhat larger than theory indicates. The additional expense is trifling, and we can partially close them if found necessary.

In regard to new houses, there can be no excuse for neglecting to provide for perfect ventilation, but it must be admitted that difficulties sometimes occur in houses already built. Many of us are tenants, and do not like to spend money in improving other people's property, and landlords are not generally eager to spend money solely for the good of their tenants. But the matter

demands the serious attention of every householder, and if structural improvements are necessary he cannot weigh the trifling cost of these against the health of his family.

Much, however, may be done by the very simplest means. We can open our doors and windows. The bye-laws of a neighbouring local board, referring to lodging-houses, contains this order:—"The windows of every sleeping room in the house are to be kept open to their full width from nine to eleven o'clock every morning, and from two to four every afternoon (weather permitting), unless the sickness of any inmate of such room should require the window thereof to be closed; and during the times such windows are opened the bedclothes of every bed in the room shall be turned down and freely exposed to the air."

It is better, of course, to open both top and bottom sash, but the upper one is the most important. There can be no excuse for neglecting to open bedroom windows; in the roughest weather the top sash may be safely lowered an inch or so for a short time, and even where there is sickness the patient can be temporarily shielded from draughts, if such exist, whilst the air in the room is changed.

A young lady, the energetic mistress of a country house on the Northumberland coast, recently told me of a very simple expedient she had adopted to ventilate her bedrooms. These were low, the window frames were old, and the top sash in every case fixed. As the old sashes would not bear altering, and new ones could not be had, she instructed a joiner to bore as many holes as possible in the top rail of each fixed sash, and the effect was that the rooms, which always smelt close and fusty before, to use her own words, felt clean and healthy afterwards.

An objection is sometimes raised to opening windows, on the pretence of smells and nuisances outside, but bad as the air may be outside, it is almost invariably worse inside.

As to the effect of deficient ventilation, this may not be death; it may not even be specific disease, but it will unquestionably be a lowering of the physique, thereby rendering us more liable to sickness, more prone to idleness, and weakening to both body and mind. Amongst our smaller cottage homes it is to be feared that other ill effects result, as men, and sometimes women too, resort to the lofty, clean, and well lit gin palace for an antidote to the languor induced by their own unventilated, dark, and in many cases dirty, dwellings.

There is a class in all large towns which it is difficult for Christianising agencies to reach, and we are told that it is next to impossible to improve their morals until we have improved their dwellings. Whilst freely admitting the need of sanitary improvements in many low class districts, I venture to assert that advice and moral suasion are even more needed.

It is possible to keep any cottage clean, and with very little trouble also, to ventilate the rooms, yet how seldom we find, on looking from the railway carriages as we pass through a town, that people open their windows. Let district visitors, therefore, and all who have an opportunity, impress upon the poor the importance of ventilating their rooms by this easy and simple way. Let us, however, if need be, first put our own house in order, and then we can advise others with a better grace to go and do likewise.

# THE LEGAL POSITION OF LANDLORDS, TENANTS, AND SANITARY AUTHORITIES.

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BY J. E. CRAWFORD MUNRO, LL.M

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THE legal position of Landlords, Tenants, and Sanitary Authorities is so wide a subject for a single lecture that I can only attempt to touch on some of the leading aspects of the question. If I treat the subject chiefly from the point of view of the tenant it is not because the position of a landlord or sanitary authority is unimportant, but because the average tenant is more helpless and knows less about his rights than the average landlord or sanitary authority. It will be convenient to consider, first, the position of a person who is going to take a house; secondly, the position of a tenant whilst in occupation as regards his landlord on the one hand and the local sanitary authority on the other. Then, after referring to the legal position of lodgers, I shall deal with some of the powers of sanitary authorities.

## POSITION OF A PERSON ABOUT TO TAKE A HOUSE.

*Sanitary Condition.*—Before taking a house the tenant ought to have it carefully examined by a qualified sanitary engineer, in order to ascertain if it is in a good sanitary condition. The law imposes this duty upon the tenant, and not upon the landlord. If the tenant take the house without having it inspected he does so at his own risk. The house may be built over a cesspool or an ashtip, the drains may not be connected with the sewers, the pipes may not be properly ventilated; and if, as a result, any member of your family take a disease and die, you will have no remedy or claim for damages

against your landlord. Not long ago the child of a tenant of a house in Rusholme was taken ill with typhoid fever ; three months afterwards a second child was laid up with laryngitis and died ; and soon afterwards a third child took diphtheria and died within a week. The doctor who attended the children certified that the illness of the children was due to blood poisoning, caused by the emanations from the drains. The tenant left the house for a fortnight until it was disinfected, and then returned, but only to be laid up with sore throat. A sanitary engineer was then called in, and he certified that the house was quite unfit for habitation, owing to its insanitary condition. The tenant left the house, paying rent up to and including the then running quarter. The landlord sued him for another quarter's rent, because he had not given the usual notice to quit, and he was obliged to pay, as the judge held that when you take a house the landlord incurs no responsibility for its sanitary condition.

You may, however, make a landlord responsible if he has given you a warranty that the house is fit for habitation. Landlords do not usually give this ; but anyone intending to take a house ought always to ask the landlord for a warranty. Were the custom of giving warranties once established, landlords would soon find it their interest so to build houses that the drainage could be easily and expeditiously examined. Such a warranty ought, if possible, to be obtained in writing, as a written document is much better proof of what has taken place between the parties than oral evidence or mere conversation. But even if the landlord gives you a warranty, prudence will always suggest that the house ought to be examined. The warranty will only enable you to recover damages ; it will not prevent you catching disease ; and the guinea spent in investigating the sanitary condition of the house will be amply repaid in the confidence you will have of freedom from catching those deadly diseases that are so intimately connected with our drains and sewers.

*Furnished Houses.*—In the case of a furnished house the law has placed a tenant in a better position. A lady once took a furnished house in a fashionable part of London for three months. On taking possession, she noticed an unpleasant smell in the house, and at once left it. The inspector of nuisances examined it, and found that the drains were out of repair, that there was a cesspool under the pantry, whilst under the basement he discovered a considerable amount of stagnant water. The landlord sued the

lady for the rent, but it was held that when a man lets a ready-furnished house he does so under the implied condition or obligation that the house is in a fit state to be inhabited, and that under the circumstances the lady was justified in leaving the house and refusing to pay the rent. (*Wilson v. Finch Hatton*, 2 Ex. D., 336.)

If the house be insanitary, the Local Authorities have power to compel the owner to put the drains in proper order (Public Health Act, s. 23), but their powers seem to be limited to this, except where the condition of the house is such as to amount to a nuisance. The tenant, by taking a house in which the drains are not in proper order, may incur the risk of having to bear the expense of repairing the same in case the state of the drains prove eventually to be a public nuisance.

#### POSITION OF TENANT DURING TENANCY IN RELATION TO HIS LANDLORD.

*Rates.*—As a general rule, all rates and taxes fall on the occupier. The chief exceptions are the land tax and property tax, which fall on the landlord. The tenant is bound to pay both these taxes in the first instance, but may deduct the same from the rent. When a house is taken on lease or by an agreement, a clause is usually inserted regarding the payment of taxes by the tenant. Before signing such an agreement you ought to be most careful to ascertain what rates and taxes are included. For instance, if you promise "to pay all taxes generally," or to pay your rent "free and clear from all manner of taxes, charges, and impositions whatsoever," you will find that you are bound to pay the land tax, which, in the absence of such promise, would have fallen on the landlord. As a rule, the landlord has to bear the expense of making new sewers, but the rate will fall on the tenant if he agreed with his landlord to pay "all outgoing." It may be that the street opposite the house has not been made, and here care is required to avoid a liability the tenant does not contemplate.

*Repairs.*—Leases generally contain a covenant relating to repairs, and here again the tenant ought to act with the greatest caution. If he undertake to "keep the premises in repair" he will be bound to have them in repair *at all times* during the term, and if they are at any time out of repair he has committed a breach of covenant for which he may be made liable. No covenant of this kind ought ever to be entered into by a tenant. He ought always to insist on such words as "reasonable wear and tear excepted" being

inserted. Such a clause will prevent misunderstandings arising during the tenancy, and will prevent any claim for dilapidations at its determination.

If a tenant covenant "to repair and keep in repair," and the house be burned down, he will have to rebuild the house at his own cost, and continue to pay the rent as if no fire had occurred. A covenant to repair ought therefore to contain the words "damage by fire excepted," and besides this, the landlord ought to be bound to rebuild the premises, and a stipulation ought to be inserted as to payment of rent during the period of rebuilding.

In Manchester, I believe, houses are usually let on a yearly tenancy. When that is the case the tenant is not liable for general repairs. His duty is to keep the house wind and water tight. He is also liable to do fair tenantable repairs, *e.g.*, to put in windows or repair doors injured by him. He is not bound to do any substantial or lasting repairs, such as new flooring or new roofing.

*Determination of Tenancy.*—No one should ever take a house without an express agreement as to time when a notice to quit may be given and as to the length of the notice to be so given. It is a mistake to suppose that because you pay your rent quarterly you may give a quarter's notice at any time. If you take a house at so much a year, though the rent be paid quarterly, you will be regarded as a tenant from year to year, and you cannot end the tenancy except at the expiration of any year ending on the day on which the tenancy began. When, therefore, you desire to be able to leave your house at the end of any quarter, you ought to have an express understanding with the landlord to this effect.

*Fixtures.*—It is important that a tenant should know his position as regards fixtures put up by him during his term. The principle on which his rights depend is this. All fixtures erected by him by way of *ornament* or *convenience* may be taken away before the term expires, provided they do not amount to a permanent improvement and can be removed without material injury or damage to the freehold. The following articles have been held removable: Hangings, tapestry, pier glasses nailed to the wall, marble or other ornamental chimneypieces, window blinds, grates, ranges, and stoves though fixed in brickwork, fixed tables, pumps, cupboards fixed with holdfasts, bookcases standing on brackets and screwed to the walls. When it is said that the tenant can remove these things, this must be understood as implying that he can only do so if the removal does not occasion any substantial injury to

the walls. For instance, a conservatory affixed to the house and communicating with it by doors, cannot be removed.

POSITION OF THE TENANT DURING TENANCY IN RELATION TO  
THE LOCAL SANITARY AUTHORITY.

*House Refuse.*—"If a Local Authority who have themselves taken or contracted for the removal of house refuse from premises, or the cleansing of earthclosets, privies, ashpits, and cesspools fail, without reasonable excuse after notice in writing from the occupier of any house within their district requiring them to remove any house refuse, or to cleanse any earthcloset, privy, ashpit, or cesspool belonging to such house or used by the occupier thereof, to cause the same to be removed or cleansed, as the case may be, within seven days the Local Authority shall be liable to pay to the occupier of such house a penalty not exceeding five shillings for every day during which such default continues after the expiration of the said period" (s. 43, Public Health Act, 1875). I have quoted this important section of the Public Health Act as an impression prevails amongst many people that the Sanitary Authority is only bound to remove all house refuse at certain times. It will be observed that the section has no such qualifying clause, and that the Sanitary Authority can be compelled to remove all refuse as quickly as may be desirable.

*Nuisances.*—"Nuisance" is a word that has a very wide meaning. Lord Mansfield defined it as anything that "renders the enjoyment of life or property uncomfortable." A smoky chimney, a foul drain, or a pigsty, may under certain circumstances amount to a nuisance. A distinction is drawn between what are called private nuisances and public nuisances. A private nuisance is something injurious to some definite person or number of persons. A public nuisance is something injurious to the public generally. Special remedies are provided by the law when the nuisance affects the public generally. The Public Health Act of 1875, s. 91, mentions the following amongst others as amounting to a public nuisance:—

1. Any premises in such a state as to be a nuisance or injurious to health.
2. Any pool, ditch, gutter, watercourse, privy, urinal, cesspool, drain, or ashpit so foul or in such a state as to be a nuisance or injurious to health.
3. Any animal so kept as to be a nuisance or injurious to health.

4. Any accumulation or deposit which is a nuisance or injurious to health.

5. Any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of the same family.

6. Any chimney sending forth black smoke in such quantity as to be a nuisance.

In connection with this last point, it ought to be noticed that if any tenant permits any chimney in his house to catch fire owing to the omission, neglect, or carelessness of himself or his servant, he is liable to a penalty of ten shillings (10 and 11 Vic., c. 89, s. 31.)

Now, it is the duty of the Local Sanitary Authority to put an end to all public nuisances within their district. The first step to take is to give notice in writing to the owner or the tenant of the premises on which the nuisance exists, requiring him to abate the nuisance within a certain time (s. 94). If the notice be not complied with, either the owner or the occupier are then to be summoned (s. 95) before a justice of the peace, and if he be satisfied that a nuisance exists, he will make an order requiring the notice to be complied with, and may impose a penalty not exceeding £5 (s. 96). If this order of the court be not obeyed, a penalty not exceeding 20s. a day will be incurred, and what is more important, the Local Authority may execute the work necessary to abate the nuisance (s. 98). Who is to bear the cost of abating the nuisance? The answer is, the person who caused the nuisance. If the landlord caused it, he must pay; if the tenant, he must pay; if the nuisance be due to both, then both must bear the expense of abatement. The occupier may, however, be called upon to pay the expense in the first instance, but then he is allowed to deduct from his rent all that he pays on behalf of his landlord. The tenant cannot be called upon to pay the Local Authority more than the rent then due (s. 104), and if, after notice has been given by the Sanitary Authority to the tenant to pay the rent to them, the landlord, before such actual payment, puts in a distress for the rent, the rent ought to be paid to the landlord, and not to the Local Authority, otherwise the tenant would be liable to double rent.

I have been informed that Local Boards are not always as energetic in putting down nuisances as might be desired. In such cases there is nothing to prevent any individual affected by the

nuisance from taking adequate steps to abate the same. The first step to take is to draw the attention of the Local Board to the nuisance, and request them to set the law in motion. If this course is not effectual, complaint ought to be made under the 106th section of the Public Health Act to the Local Government Board in London to the effect that the Local Authority have made default in their duty in relation to the nuisance. This complaint should be made in the form of a memorial, and be signed by as large a number of persons as possible, though it is sufficient if signed by one person only. In all probability this course will be effective. The Local Government Board have ample powers to abate the nuisance, and can recover the expenses from the Local Board. It is desirable, though not necessary, that the memorial be supported by some evidence—a report signed by a competent or skilled third person will always add weight to the statements in the memorial itself. All communications ought to be addressed to the Local Government Board, Whitehall, London.

Another method of procedure is this. Complaint may be made to a justice of the peace, under section 105 of the Public Health Act, and a summons be obtained against the owner or occupier of the premises on which the nuisance exists, and then the court, if satisfied that there is a nuisance, will order the same to be abated. In these days persons always hesitate before enforcing a public duty by taking legal proceedings; and the trouble of getting witnesses is often so great that this procedure before justices is not often resorted to. It is a method of proceeding that entails little expense, and all costs can be recovered.

#### LODGERS.

Lodgings are usually let by the week, but in every case a written agreement ought to be signed by the parties, but it will be quite sufficient if the tenant writes a letter stating the terms on which the lodgings are to be taken. If the lodger leaves without paying his rent, the rent cannot be recovered unless there was some agreement in writing to take the rooms.

If the landlord of the house puts in a distress for rent, what is the position of the lodger? If he desires to protect his goods he ought at once to serve a written notice on the landlord or the bailiff making the distress, stating "that the lodging-house keeper has no right of property or beneficial interest in the furniture, goods, or chattels belonging to him, and distrained, or threatened

to be distrained upon, and that such furniture, goods, or chattels are his property." He should also state what rent is due from him and for what period to the lodging-house keeper, and offer to pay such rent to the bailiff or landlord making the distress. To this notice he should add an inventory of all his property. If the landlord or bailiff does not restore the goods, the lodger should at once apply to the nearest stipendiary magistrate, who will make an order for the restoration of the goods.

#### SANITARY AUTHORITIES.

*Unhealthy Houses.*—Local Boards have ample powers for remedying the evils that arise from houses being unfit for human habitation (Public Health Act, s. 94). The Board may serve a notice on the owner requiring him to put the house in a habitable state within a certain time. If he neglects to do so, they may summon him before a justice, and the justice may prohibit the using of the house until it is rendered habitable (Public Health Act, s. 97). They can also prevent houses from being overcrowded, and if there be houses in any district unfit for human dwellings, it is due to the Sanitary Authority of the district not enforcing the powers given them by the various acts of Parliament.

*The Building of Houses.*—Every Urban Authority has power to make byelaws "with respect to the structure of walls, foundations, roofs, and chimneys of new buildings, for securing stability and the prevention of fires, and for purposes of health" (Public Health Act, s. 157). Though it is true that byelaws require the confirmation of the Local Government Board (Public Health Act, s. 184), it is to be regretted that advantage has not been taken of this section to put an end to the jerry building that is fast destroying the reputation of some of the pleasantest suburbs of Manchester and other towns. Houses have been erected within the last five years, not many miles from where we are now, utterly unfit for habitation. Yet the houses are called "villas," and to anyone looking at them from the outside present a not unattractive appearance. The unfortunate tenant who in the summer time is led to take one of these villas, will, before the following winter be over, find to his cost that such is the workmanship, that the villa will keep out neither the wind nor the rain; that the cistern and pipes are so arranged that the first frost will see his house flooded with water; and that the woodwork has so shrunk that warmth and comfort are an impossibility. Such houses are dangerous to health in every sense of the phrase.

A doctor told me this winter that during one period of frost he was attending the children in every house in a certain row of "villas," owing simply to the fact that the nursery in each house was entirely unfit for anyone, child or adult, to occupy. The fact is, houses are no longer built to live in; they are built to create a rent, to be mortgaged, to be sold. Local Boards, it is but right to add, are often hampered by the refusal of the Local Government Board to authorise byelaws absolutely necessary in the interests of the health of the districts. It is to be hoped that the Local Boards to be formed under the proposed Local Government Bill will possess more ample powers than they now enjoy in regards to building regulations.



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